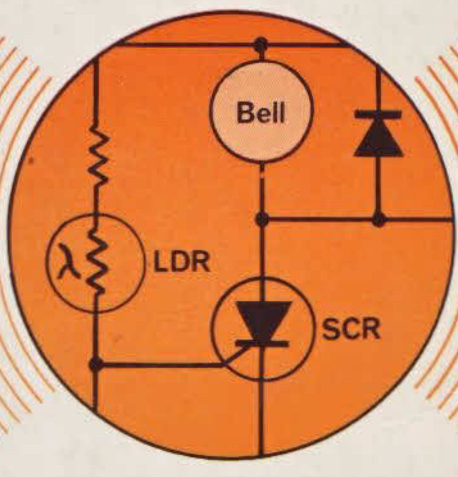
# 110 ELECTRONIC ALARM PROJECTS FOR THE HOME CONSTRUCTOR

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# PREFACE

Electronic alarms have a multitude of applications in the home, in industry, and in the car. They can be designed to be activated by physical contact or the proximity of a body, or by variations in light and heat levels, or by variations in voltage, current, resistance or some other electrical property. They may be designed to give high-level audible outputs, as in the case of burglar alarms, or low-level visual outputs, as in the case of instrumentation alarms. One hundred and ten useful alarm circuits, of a variety of types, are shown in this volume. The operating principle of each circuit is explained in concise but comprehensive terms, and brief constructional notes are given where necessary.

The volume is divided into seven chapters. The first five are devoted to alarm circuits that can be used in the home and in industry, including contact-operated alarms, burglar alarms, temperature alarms, light-sensitive alarms, proximity and touch alarms, power-failure alarms, and sound and vibration alarms. Chapter six is devoted to automobile alarm circuits, and gives details of immobilisers and anti-theft alarms, ice-hazard alarms, overheat alarms, and low-fuel-level alarms. The final chapter is devoted to instrumentation alarm circuits, and shows alarms that can be activated by a.c. or d.c. currents or voltages or by resistance. The circuits will be of equal interest to the electronics amateur, student and engineer.

All the circuits described have been designed, built and fully evaluated by the author. They are designed around a variety of types of readily available semiconductor devices of American manufacture. Most of the

circuits are designed around standard bipolar transistors, or an 8-pin dual-in-line type 741 operational amplifier, or a type CD4001 quad 2-input COS/MOS NOR gate digital IC. Some circuits have an SCR output stage, and are intended to activate an alarm bell or buzzer directly. In this latter case, the SCR is a type C106Y1 or equivalent, and is intended to be used in conjunction with a self-interrupting bell or buzzer with a mean current rating of less than 2 A and a voltage rating that is 1.5 V less than that of the circuit's power supply.

The outlines and pin connections of all semiconductors mentioned in the volume are given in the Appendix, as an aid to construction. Unless otherwise stated, all resistors used in the circuits are standard half-watt types.

# CONTENTS

CHAPTER 1

# CONTACT-OPERATED ALARM CIRCUITS

Contact-operated alarms can be simply described as alarm systems that are activated by the opening or closing of a set of electrical contacts. These contacts may take the form of a simple push-button switch, a pressure-pad switch, or a reed-relay, etc. The actual alarms may be designed to give an audible loudspeaker output, an alarm-bell output, or a relay output that can be used to operate any kind of audible or visual warning device. The alarm system can be designed to give non-latch, self-latch, or one-shot operation.

Contact-operated alarms have many practical applications in the home and in industry. They can be used to attract attention when someone operates a push switch, to give an automatic warning when someone opens a door or window or treads on a pressure-pad, or to give an alarm indication when a piece of machinery moves beyond a preset limit and activates a microswitch, etc. A wide range of practical contact-operated alarm circuits are described in this chapter.

### Alarm-bell & relay-output alarm circuits

The simplest possible type of contact-operated alarm circuit consists of an alarm bell in series with a normally-open (n.o.) switch, the combination being wired across a suitable battery supply, as shown in *Figure 1.1.* Any number of n.o. switches can be wired in parallel, so that the alarm operates when any one or more of these switches is closed. This type of circuit gives an inherently non-latch form of

operation, and has the great advantage of drawing zero standby current from its supply battery.

A major disadvantage of the simple *Figure 1.1* circuit is that it passes the full alarm bell current through the n.o. operating switches, so these

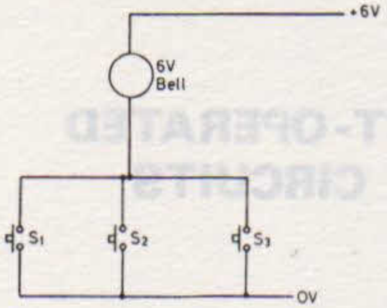



*Figure 1.1 Simple non-latch close-to-operate alarm circuit*

switches must be fairly robust types. One simple way round this problem is shown in *Figure 1.2a.*

Here, the n.o. operating switches are wired in series with the coil of a 6 V relay, and the relay contacts are wired in series with the alarm bell; both combinations are wired across the same 6 V supply. Thus when the switches are open the relay is off, so the relay contacts are open and the alarm bell is inoperative. When one or more of the switches is

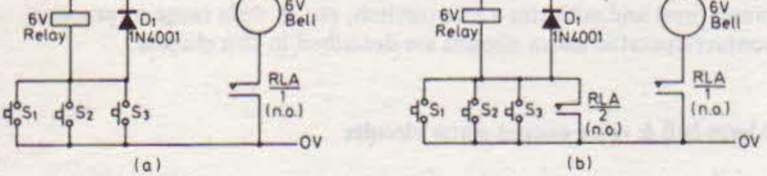



*Figure 1.2 Relay-aided close-to-operate alarms: (a) non-latching; (b) self-latching*

closed the relay turns on, so its contacts close and operate the alarm bell. Note in the latter case that the switches pass a current equal to that of the relay coil only, and can thus be fairly delicate types such as reed-relays, etc. Also note that a silicon diode is wired across the relay

coil, to protect the switches against damage from the back e.m.f. of the coil.

The *Figure 1.2a* circuit gives a non-latch form of operation, in which the alarm operates only while one or more of the operating switches is closed. If desired the circuit can be made self-latching, so that the relay and the alarm lock on as soon as one or more of the n.o. switches is closed, by wiring a spare set of n.o. relay contacts in parallel with the n.o. operating switches, as in *Figure 1.2b.*

An alternative solution to the switch-current problem is shown in *Figure 1.3a.* Here, a general-purpose silicon controlled rectifier (SCR)

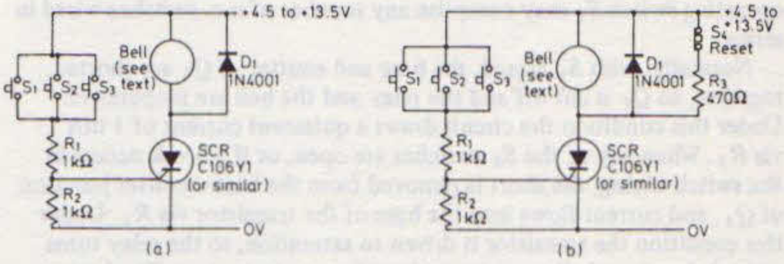



*Figure 1.3 SCR-aided close-to-operate alarms: (a) non-latching; (b) self-latching*

is wired in series with an inexpensive self-interrupting alarm bell, and the SCR has its gate current derived from the positive supply line via current-limiting resistor $R_1$ and via the n.o. operating switches. $R_1$ and the switches pass a current of only a few milliamps.

Normally, when the switches are open, the SCR is off and the alarm bell is inoperative. When one or more of the switches is closed, gate current is applied to the SCR via $R_1$, so the SCR turns on and the alarm bell operates. Since the operating current of a self-interrupting alarm bell is applied in a series of pulses via the built-in self-energising vibration contacts of the bell, the simple *Figure 1.3a* SCR circuit gives a non-latch type of operation when it is used with this type of alarm device.

If desired, the *Figure 1.3a* circuit can be made to give self-latch operation by simply wiring a shunt resistor across the bell, as shown in *Figure 1.3b,* so that the SCR current does not fall below its latching value when the bell goes into the self-interrupting mode.

Note that the SCR used in the *Figure 1.3* circuits has a current rating of only 2 A, so the alarm bell must be selected with this point in mind. Alternatively, SCRs with higher current ratings can be used in place of the device shown, but this modification may also necessitate changes in the $R_1$ and $R_3$ values of the circuit.

A major weakness of the *Figure 1.1* to *1.3* circuits is that they do not give a 'fail-safe' form of operation, and give no indication of a fault condition if a break occurs in the contact-switch wiring. This snag is overcome in circuits that are designed to be activated via normally-closed (n.c.) switches, and a typical circuit of this type is shown in *Figure 1.4*.

Here, the coil of a 12 V relay is wired in series with the collector of transistor $Q_1$, and bias resistor $R_1$ is wired between the positive supply line and the base of the transistor. The alarm bell is wired across the supply lines via a set of n.o. relay contacts, and the n.c. operating switch is wired between the base and emitter of the transistor. Note that operating switch $S_1$ may comprise any number of n.c. switches wired in series.

Normally, with $S_1$ closed, the base and emitter of $Q_1$ are shorted together, so $Q_1$ is cut off and the relay and the bell are inoperative. Under this condition the circuit draws a quiescent current of 1 mA via $R_1$. When any of the $S_1$ switches are open, or if a break occurs in the switch wiring, the short is removed from the base–emitter junction of $Q_1$, and current flows into the base of the transistor via $R_1$. Under this condition the transistor is driven to saturation, so the relay turns on and the alarm bell operates as the relay contacts close. The basic *Figure 1.4* circuit can, if desired, be made to give self-latch operation by wiring a spare set of n.o. relay contacts between the collector and emitter of $Q_1$, as shown dotted in the diagram.

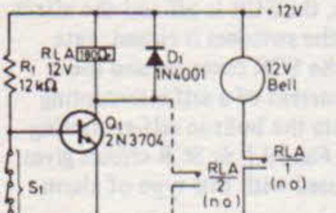


*Figure 1.4 Simple break-to-operate alarm draws 1 mA standby current*

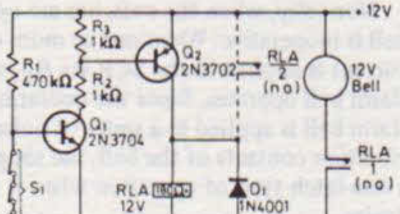


*Figure 1.5 Improved break-to-operate alarm draws 25 µA standby current*

Thus the *Figure 1.4* circuit gives automatic fail-safe operation, but draws the fairly high quiescent or standby current of 1 mA. This standby current can readily be reduced to a mere 25 µA by interposing a two-transistor amplifier stage between the contact switch and the relay, as shown in *Figure 1.5*.

Here, the base current of $Q_2$ is derived from the collector of $Q_1$ via $R_2$, and the base current of $Q_1$ is derived from the positive supply line via $R_1$. Consequently, when $S_1$ is closed both $Q_1$ and $Q_2$ are cut off, so the relay and the alarm bell are inoperative, but when $S_1$ is open both transistors are driven to saturation and the relay and the alarm bell are driven on. The circuit can be made self-latching by wiring a spare set of n.o. relay contacts between the collector and emitter of $Q_2$, as shown dotted in the diagram.

If desired, the standby current of the *Figure 1.5* circuit can be reduced to a mere 1 μA or so by using an inverter-connected COS/MOS gate in place of $Q_1$, as shown in *Figure 1.6.* The gate used here is taken

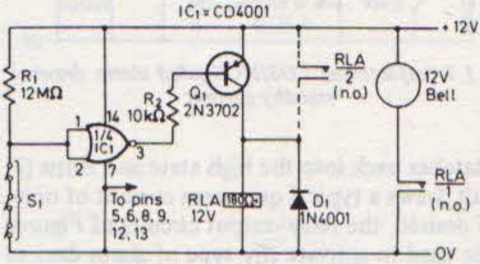



*Figure 1.6 COS/MOS-aided break-to-operate alarm draws 1 μA standby current*

from a CD4001 quad two-input NOR gate IC, and the remaining three unused gates of the device are disabled by taking their input pins to ground, as indicated. The inverter-connected COS/MOS gate has a virtually infinite input impedance, so $R_1$ can be given almost any resistance value. Ultimately, the minimum standby current of the circuit is limited only by the value of $R_1$ and the leakage current of $Q_1$.

The *Figure 1.6* circuit can be made self-latching by wiring a spare set of n.o. relay contacts between the collector and emitter of $Q_1$, as shown dotted in the diagram. Alternatively, the circuit can be made to self-latch by connecting two of the NOR gates of the CD4001 IC as a bistable multivibrator, as shown in *Figure 1.7.* Note that the remaining two unused gates of the IC are disabled by taking their inputs to ground.

The operation of the *Figure 1.7* circuit is such that the output of the COS/MOS bistable circuit goes low and self-latches if $S_1$ is momentarily opened or if the $S_1$ contact leads are interrupted. As the

output of the bistable goes low it turns on the relay and the alarm bell via $Q_1$. Once the bistable has latched the alarm bell into the 'on' state, it can be reset into the standby 'off' mode by closing $S_1$ and momentarily operating 'reset' switch $S_2$, at which point the output

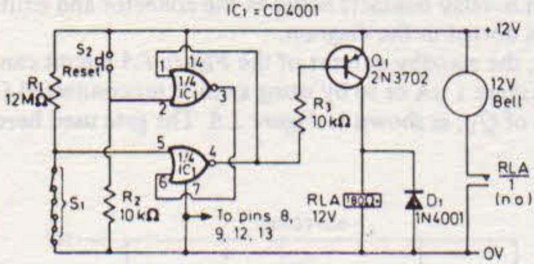



*Figure 1.7 Self-latching COS/MOS-aided alarm draws 1 μA standby current*

of the bistable latches back into the high state and turns $Q_1$ off. The *Figure 1.7* circuit draws a typical quiescent current of only 1 μA or so.

Note that, if desired, the relay-output circuits of *Figures 1.2* and *1.4* to *1.7* can be used to activate any type of alarm devices via their n.o. relay contacts, and are not restricted to use with alarm bells only.

**Loudspeaker-output alarm circuits**

Contact-operated alarm circuits can be designed to produce electronically-generated alarm signals directly into loudspeakers. Such systems can be made to produce a variety of sounds, at a variety of power levels, and may be designed around a number of types of semiconductor devices.

The most useful type of semiconductor device for this particular application is the COS/MOS digital integrated circuit. In particular, the CD4001 quad two-input NOR gate IC has the outstanding advantages of drawing virtually zero standby current, of having a virtually infinite input impedance, of tolerating a wide range of supply-rail voltages, and of being so versatile that it can be used in a whole range of waveform-generating applications. *Figures 1.8* to *1.16* show a variety of ways of using a single CD4001 IC to make contact-operated loudspeaker-output alarm circuits.

*Figure 1.8* shows the circuit of a low-power contact-operated 800 Hz (monotone) alarm generator. Here, two of the gates of a CD4001 are

connected as a gated 800 Hz astable multivibrator, and the remaining two unused gates of the device are disabled by taking their inputs to ground. The action of this astable is such that it is inoperative, with its pin 4 output terminal locked to the positive supply rail, when its pin 1 input terminal is high (at positive-rail voltage), but is operative and acting as a square-wave generator when its input is low (tied to the zero-volts line). The frequency of the astable is determined by the values of $R_1$ and $C_1$.

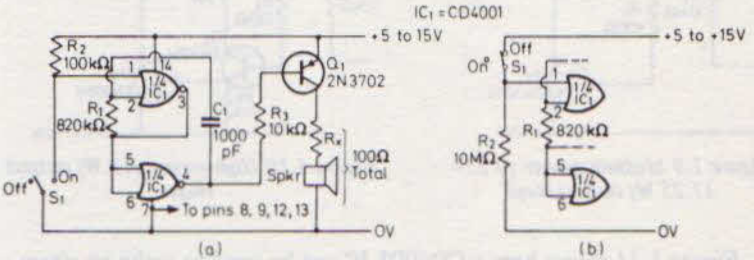



*Figure 1.8 (a) Low-power 800 Hz close-to-operate alarm generator. (b) Modification for break-to-operate version*

Thus, when the input terminal is high, zero base-current is fed to $Q_1$, so the circuit is inoperative and passes only a small leakage current; but when the input is low the astable is operative and generates a square-wave 'tone' signal in the speaker via $Q_1$. Note therefore that the circuit can be activated via n.o. contacts by using the input connections shown in *Figure 1.8a,* or by n.c. contacts by using the input connections shown in *Figure 1.8b.* In the latter case the circuit draws a standby current of roughly 1 $\mu$A via bias resistor $R_2$.

The basic *Figure 1.8* circuit is intended for low-power applications only, and can be used with any speaker in the range 3–100 Ω, and with any supply in the range 5–15 V. Note that resistor $R_x$ must be wired in series with the speaker, and must be chosen so that the total series resistance of $R_x$ and the speaker approximates 100 Ω, to keep the dissipation of $Q_1$ within acceptable limits. The actual power-output level of the circuit depends on the individual values of speaker impedance and supply voltage that are used, but is of the order of only a few milliwatts.

If desired, the power output can be boosted to a more useful level by using the medium-power output-stage circuit of *Figure 1.9.* The output power of this circuit again depends on the supply-rail and speaker-impedance values used, and may vary from 0.25 W when a

25 Ω speaker is used with a 5 V supply, to 11.25 W when a 5 Ω speaker is used with a 15 V supply. Alternatively, the output level can be boosted to about 18 W by using the high-power output stage of *Figure 1.10*.

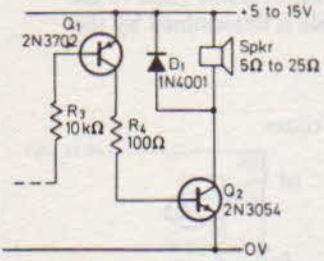



*Figure 1.9 Medium-power (0.25–11.25 W) output stage*

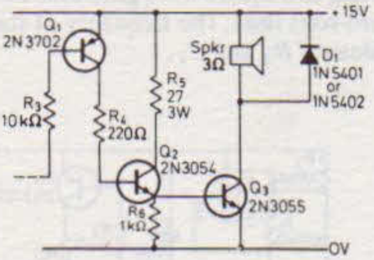



*Figure 1.10 High-power (18 W) output stage*

*Figure 1.11* shows how a CD4001 IC can be used to make an alarm that generates a pulsed 800 Hz tone when its contacts are operated. Circuit operation is quite simple. The two left-hand gates of the IC are wired as a low-frequency (roughly 6 Hz) gated astable multivibrator that is activated via the contact switches, and the two right-hand gates

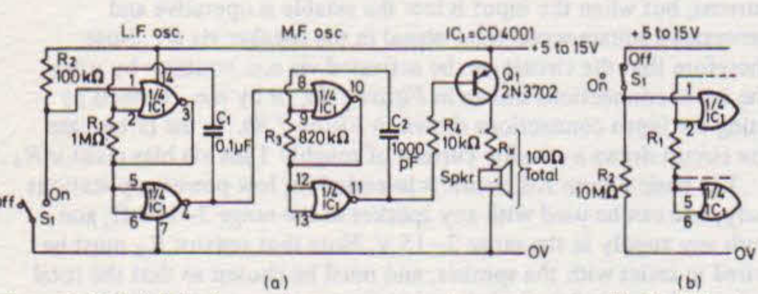



*Figure 1.11 (a) Pulsed-tone close-to-operate alarm generator. (b) Modification for break-to-operate version*

are wired as an 800 Hz astable multivibrator that is activated via the 6 Hz astable.

Normally, when the pin 1 input terminal of the circuit is high, both astables are inoperative and the circuit consumes only a small leakage current. When the input terminal is low, on the other hand, both astables are activated and the low-frequency circuit pulses the 800 Hz

astable on and off at a rate of about 6 Hz, so a pulsed 800 Hz tone is generated in the speaker.

The *Figure 1.11* circuit can be activated via n.o. contact switches by using the input connections shown in *Figure 1.11a,* or by n.c. switches by using the connections shown in *Figure 1.11b.* If desired, the circuit's normal output power of only a few milliwatts can be boosted to as high as 18 W by replacing its $Q_1$ output stage by one or other of the *Figure 1.9* or *Figure 1.10* power-booster circuits.

*Figure 1.12* shows how the *Figure 1.11* circuit can be modified so that it produces a warble-tone alarm signal. These two circuits are

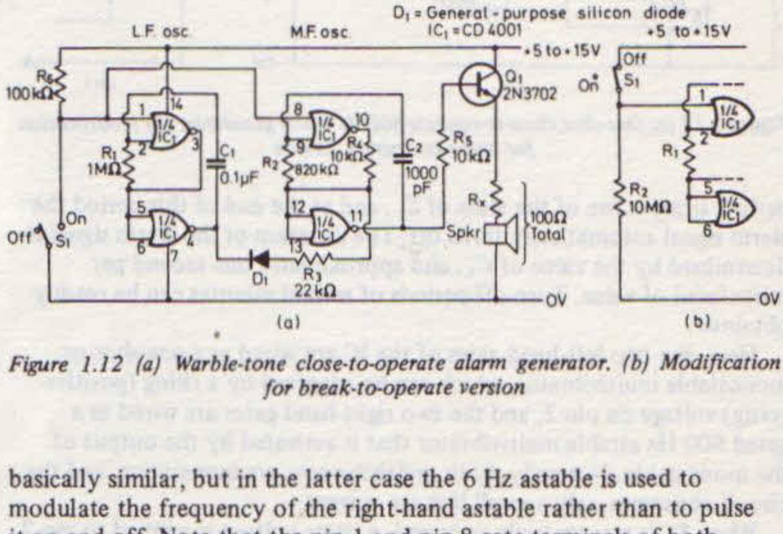



*Figure 1.12 (a) Warble-tone close-to-operate alarm generator. (b) Modification for break-to-operate version*

basically similar, but in the latter case the 6 Hz astable is used to modulate the frequency of the right-hand astable rather than to pulse it on and off. Note that the pin 1 and pin 8 gate terminals of both astables are tied together, and the astables are thus both activated directly by the contact switches. The circuit can be activated by n.o. switches by using the connections shown in *Figure 1.12a,* or by n.c. switches by using the connections shown in *Figure 1.12b.* The output power of the circuit can be boosted to a maximum of 18 W by using the power-booster stages of *Figure 1.9* or *1.10.*

The circuits of *Figures 1.8, 1.11* and *1.12* are all non-latching types, which produce an output only when they are activated by their contact switches. By contrast, *Figures 1.13* and *1.14* show two ways of using a CD4001 IC so that it gives some form of self-latch alarm-generating action.

The *Figure 1.13* circuit is that of a one-shot or auto-turn-off alarm generator. The action of this circuit is such that an 800 Hz monotone alarm signal is initiated as soon as contact switch $S_1$ is momentarily operated. This alarm signal then continues to be generated for a preset

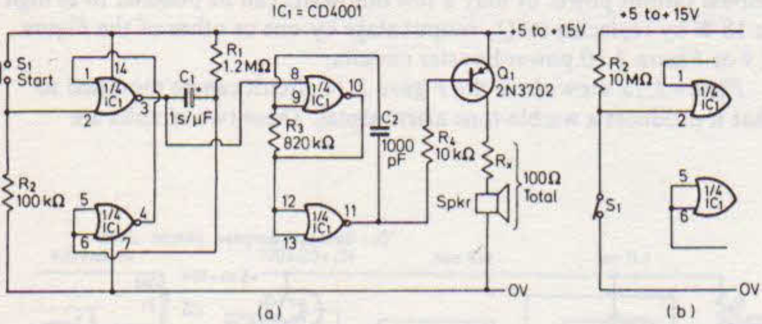



*Figure 1.13 (a) One-shot close-to-operate 800 Hz alarm generator. (b) Modification for break-to-operate version*

period, irrespective of the state of $S_1$, and at the end of this period the alarm signal automatically turns off. The duration of the alarm signal is determined by the value of $C_1$, and approximates one second per microfarad of value. Turn-off periods of several minutes can be readily obtained.

Here, the two left-hand gates of the IC are wired as a one-shot or monostable multivibrator, which can be triggered by a rising (positive-going) voltage on pin 2, and the two right-hand gates are wired as a gated 800 Hz astable multivibrator that is activated by the output of the monostable. Normally, both multivibrators are inoperative, and the circuit consumes only a small leakage current.

When $S_1$ is momentarily operated, a rising voltage is applied to pin 2 of the IC, and the monostable fires and gates the astable on, so an 800 Hz tone is generated in the speaker. At the end of the preset period the monostable automatically turns off again, so the tone ceases to be generated and the current consumption returns to leakage levels. The circuit can be reactivated again only by applying a rising voltage to pin 2 via $S_1$. The circuit can be activated by n.o. switches by using the connections shown in *Figure 1.13a,* or by n.c. switches by using the connections shown in *Figure 1.13b.*

Finally, *Figure 1.14* shows how the CD4001 can be used to make a true self-latching 800 Hz contact-operated alarm generator. Here, the two left-hand gates of the IC are wired as a manually-triggered bistable

multivibrator, and the two right-hand gates are wired as a gated 800 Hz astable multivibrator that is activated via the bistable.

Circuit action is such that the output of the bistable is normally high, so the astable is disabled and the circuit consumes only a small leakage current. When $S_1$ is momentarily operated, a positive signal is applied to pin 2 of the IC, so the bistable changes state and its output locks into the low state and activates the astable multivibrator. An 800 Hz tone signal is generated in the speaker under this condition.

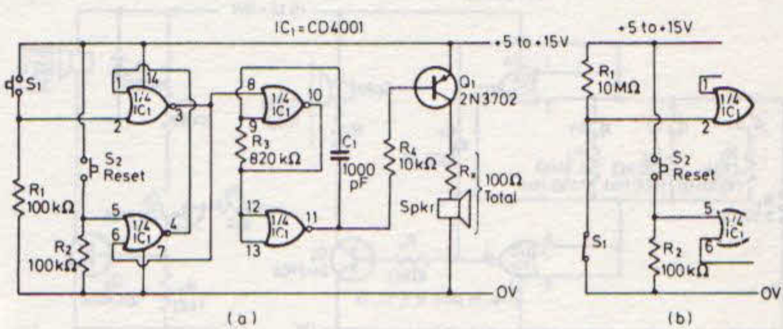



*Figure 1.14 (a) Self-latching close-to-operate 800 Hz alarm generator. (b) Modification for break-to-operate version*

Once it has been activated, the circuit can only be turned off again by removing the positive signal from pin 2 and briefly closing 'reset' switch $S_2$, at which point the circuit resets and its quiescent current returns to leakage levels.

The *Figure 1.14* circuit can be activated by n.o. switches by using the connections shown in *Figure 1.14a,* or by n.c. switches by using the connections shown in *Figure 1.14b.*

Note that the *Figure 1.13* and *1.14* circuits normally give output powers of only a few milliwatts, but that these levels can be boosted as high as 18 W by replacing their $Q_1$ output stages with the power-boosting circuits of *Figure 1.9* or *1.10.*

**Multitone generator circuits**

To conclude this chapter, *Figures 1.15* and *1.16* show the circuits of two push-button activated multitone alarm generators. These circuits have two or three sets of push-button operating switches, and the circuit action is such that each push switch causes the generation of

its own distinctive tone. These circuits have uses in 'door announcing' applications, where, for example, a high tone may be generated by operating the front door switch, a low tone by operating the back door switch, and a medium tone by operating the side door switch.

The *Figure 1.15* circuit is that of a simple three-input monotone alarm generator system. Here, two of the gates of a CD4001 IC are wired as a modified astable multivibrator, and the action is such that

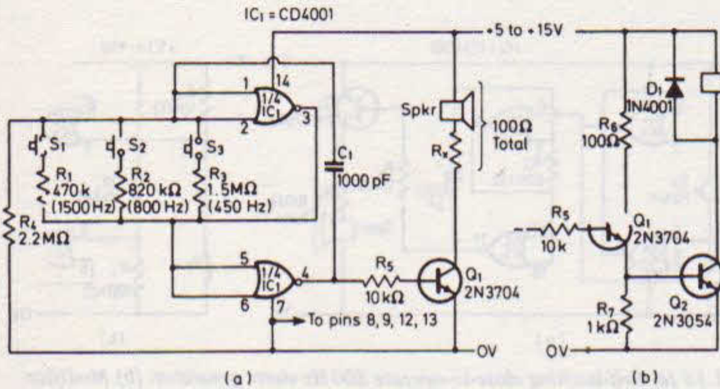



*Figure 1.15 (a) Multitone contact alarm. (b) Modification for high-power output*

the circuit is normally inoperative and drawing only a negligible leakage current, but becomes active and acts as a square-wave generator when a resistance is connected between pins 2 and 5 of the IC. This resistance must be substantially less than the 2.2 MΩ of $R_4$, and the frequency of the tone is inversely proportional to the resistance value that is used.

With the component values shown, the circuit generates a tone of roughly 1500 Hz when $S_1$ is operated, 800 Hz when $S_2$ is operated, and 450 Hz when $S_3$ is operated. Note that these tones are separated by roughly one octave each, so each push-button generates a very distinctive tone.

As in the case of the other circuits already described, the *Figure 1.15a* circuit generates an output power of only a few milliwatts. If required, this power can be boosted to as high as 11.25 W by using the power-booster stage shown in *Figure 1.15b.* As in the case of the *Figure 1.9* circuit, the final output power depends on the actual values of speaker impedance and supply rail voltage that are used.

*Figure 1.16a* shows the circuit of a two-input multitone circuit that

generates a monotone signal when one push-button is operated, or a pulsed-tone signal when the other push-button is operated.

Here, the two left-hand gates of the IC are wired as a low-frequency (approximately 6 Hz) gated astable multivibrator, and the two right-hand gates are wired as a gated 800 Hz astable multivibrator. The two multivibrators are interconnected via silicon diode $D_1$, and the circuit action is such that the low-frequency astable oscillates and activates the 800 Hz astable when $S_1$ is operated, thus producing a pulsed tone

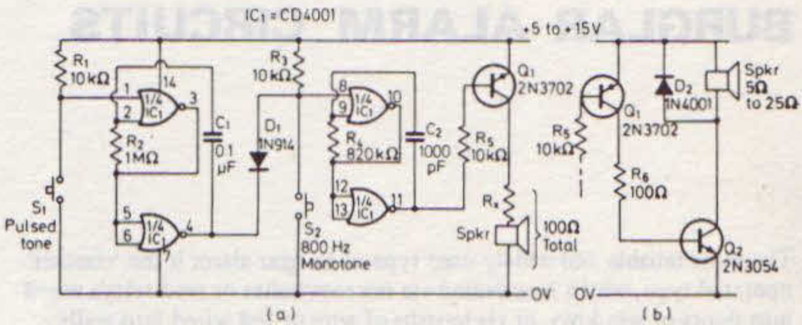



*Figure 1.16 (a) Two-input multitone contact alarm. (b) Modification for high-power output*

in the speaker, but only the right-hand 800 Hz astable operates when $S_2$ is closed, thus producing a monotone signal in the speaker.

The basic *Figure 1.16a* circuit generates an output power of only a few milliwatts. If required, this power can be boosted to as high as 11.25 W by using the power-booster stage shown in *Figure 1.16b.* The actual output power of this circuit again depends on the values of speaker impedance and supply-rail voltage that are used.

CHAPTER 2

# BURGLAR ALARM CIRCUITS

The most reliable and widely-used type of burglar alarm is the 'contact' operated type, which is activated via microswitches or reed-relays wired into doors or windows, or via lengths of wire or foil wired into walls, floors or ceilings, etc. Ideally, such systems are battery powered, consume negligible standby current, provide a relay output for operating any type of alarm generator (bell, siren, etc.), and have optional provision for incorporating 'panic', 'fire', or similar alarm facilities.

In this chapter we show a variety of basic burglar-alarm and accessory circuits that meet the above ideals, and explain how the reader can combine different circuits to produce a 'tailor-made' alarm system that meets his own specific needs. These systems can be as simple or as complex as the individual reader cares to make them. We also show three 10 W alarm-call generator circuits that can be used in place of alarm bells or sirens, and give advice on how to install a complete alarm system in the home. Most of the alarm circuits described are designed around readily available COS/MOS digital integrated circuits.

**Basic burglar-alarm circuits**

Contact-operated burglar alarms can be designed as either self-latching circuits, which turn on as soon as they are activated and then remain on indefinitely (or until their supply batteries run down), or as auto-turn-off circuits, which turn on as soon as they are activated but then

turn off again automatically after a preset period. Basic COS/MOS alarm systems of both these types are shown in *Figures 2.1* and *2.2.*

The self-latching operation of the *Figure 2.1* circuit is obtained by wiring two of the gates of CD4001 COS/MOS IC so that they act as a

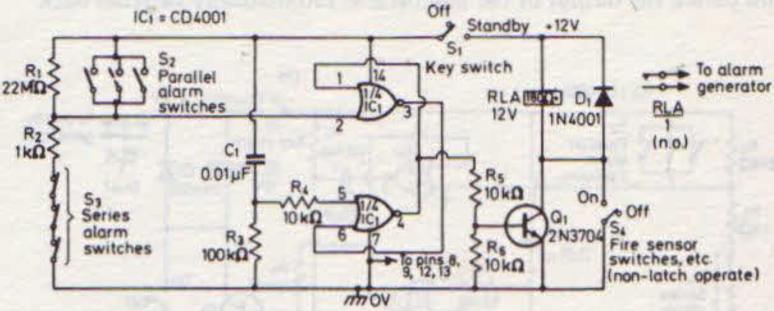



*Figure 2.1 Simple self-latching burglar alarm*

simple bistable multivibrator. The action of this bistable is such that its output (taken from pin 4) goes low and self-latches when a positive voltage or pulse is applied to pin 5, and its output goes high and self-latches when a positive voltage or pulse is applied to pin 2. Power is applied to the bistable and to the alarm sensor switches ($S_2$ and $S_3$) via key-operated switch $S_1$.

Assume, then, that $S_2$ is open and $S_3$ is closed. When key-switch $S_1$ is first set to the 'standby' position, pin 2 is held low by the potential divider action of $R_1$ and $R_2$, and a brief positive voltage pulse is fed to pin 5 from the supply line via $C_1$ and $R_3$–$R_4$. Consequently, the output of the bistable automatically goes low as soon as $S_1$ is closed. Under this condition zero base drive is applied to $Q_1$, so $Q_1$ and the relay and the alarm are all off. The circuit draws a typical current of about 1 $\mu$A in this standby mode: half of this current flows via $R_1$ and $R_2$, and the remainder as leakage via $Q_1$.

The alarm can be activated by opening any one of series-connected sensor switches $S_3$, or by closing any one of parallel-connected sensor switches $S_2$. Under this condition pin 2 of the bistable goes close to the positive supply-rail voltage, and the bistable changes mode and its output locks into the high state and switches the alarm generator on via $Q_1$ and the relay. The alarm then stays on indefinitely, and can be turned off only by opening $S_1$.

The auto-turn-off circuit of *Figure 2.2* is similar to that of *Figure 2.1,* except that the two gates of the IC are connected as a simple monostable multivibrator. The action of this monostable is such that

its output goes to the low state when a positive voltage or pulse is fed to pin 5, but goes high for a preset period when a positive-going voltage transition is applied to pin 2. The value of this preset period is determined by the time constant of $R_7$ and $C_2$, and equals roughly four minutes (0.5 s/$\mu$F of $C_2$ value) with the $C_2$ value shown. At the end of this period the output of the monostable automatically switches back

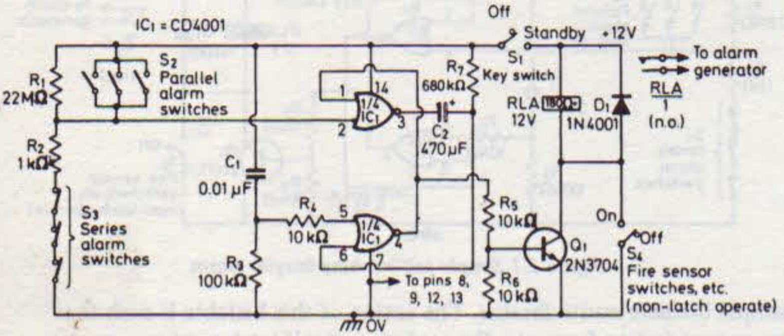



*Figure 2.2 Simple auto-turn-off burglar alarm (turn-off delay ≈ 4 minutes)*

to the low state. Note that the monostable can be triggered only by a positive-going transition of its pin 2 voltage, and its action is not influenced by 'standing' high or low voltages that may be applied to this pin.

Thus the output of the monostable automatically goes low as soon as key-switch $S_1$ is set to the 'standby' position. Under this condition the relay and the alarm are off, and the circuit consumes a typical standby current of 1 $\mu$A. The alarm can be activated by opening any one of series-connected sensor switches $S_3$, or by closing any one of parallel-connected sensor switches $S_2$. Under this condition a positive-going transition appears on pin 2 of the monostable, and its output switches into the high mode for a preset period and turns $Q_1$–$RLA$ and the alarm on. At the end of this period the output of the monostable goes low again, irrespective of the states of $S_2$ and $S_3$, and $Q_1$–$RLA$ and the alarm turn back off. The circuit can then be reset either by opening and then closing $S_1$, or by setting all $S_2$ and $S_3$ switches back to their original conditions.

Note in the *Figure 2.1* and *2.2* circuits that power is permanently applied to the $Q_1$–$RLA$ sections of the designs, even when $S_1$ is in the 'off' position. This facility enables the alarm to be activated in the non-latching mode at all times via an n.o. temperature-sensing switch

or thermostat, so that these circuits can also function as permanently-alert fire alarm systems. Any number of n.o. switches can be wired in parallel with $S_4$.

A weakness of the *Figure 2.1* and *2.2* circuits is that they give the owner no protection against intruders who may break into the house when the main alarm system is switched off. Protection against this type of intrusion can be obtained by scattering a number of series-connected n.c. 'panic' buttons around the house, so that a permanently alert self-latching alarm system can be activated manually at any time. This facility can readily be added to the *Figure 2.1* and *2.2* circuits, and *Figure 2.3* shows how it can be wired into the auto-turn-off system of *Figure 2.2*.

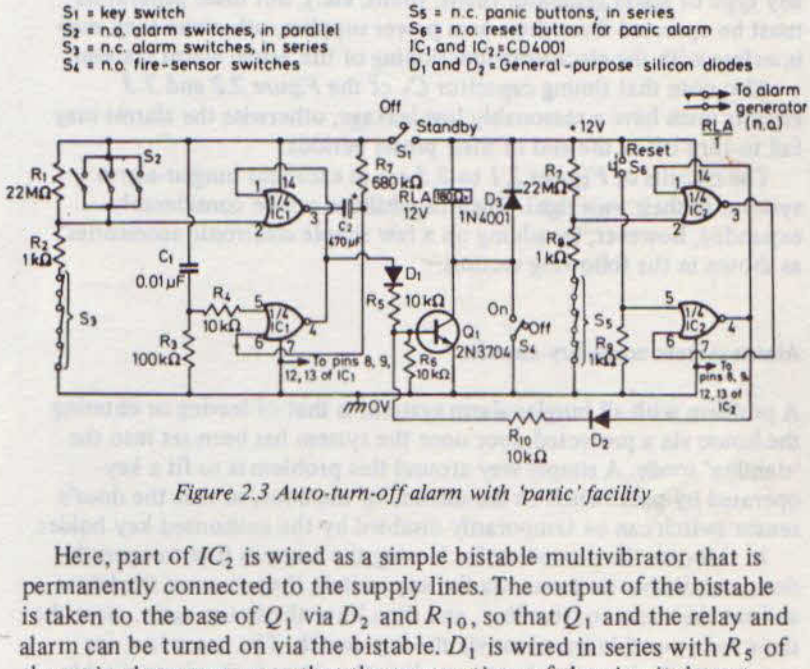



*Figure 2.3 Auto-turn-off alarm with 'panic' facility*

Here, part of $IC_2$ is wired as a simple bistable multivibrator that is permanently connected to the supply lines. The output of the bistable is taken to the base of $Q_1$ via $D_2$ and $R_{10}$, so that $Q_1$ and the relay and alarm can be turned on via the bistable. $D_1$ is wired in series with $R_5$ of the main alarm system so that the two sections of the circuit do not interact adversely. The output of the bistable is normally latched into the low state, so the relay and alarm are normally off. If any of series-connected 'panic' buttons $S_5$ are opened, the bistable immediately changes mode and its output locks into the high state and drives *RLA* and the alarm on. Once the alarm has been turned on, it can be reset to the 'off' state by briefly closing 'reset' switch $S_6$. This panic facility

adds 0.5 $\mu$A to the total quiescent current consumption of the complete alarm system.

The panic facility can be added to the *Figure 2.1* circuit by simply wiring $D_1$ in series with $R_5$, and adding $IC_2$ and its associated circuitry to the basic design.

Note in the *Figure 2.3* circuit that two independent CD4001 ICs are used. This is because all four of the gates in each IC are connected to the same supply-line points (pins 7 and 14), and in *Figure 2.3* we need to be able to remove the supply from one pair of gates while keeping it on the other. All unused pins of the ICs are tied to ground, as indicated.

Note that the relay used in each of the *Figure 2.1* to *2.3* circuits can be any 12 V type with a coil resistance of 180 Ω or greater, and with one or more sets of n.o. contacts. The contacts can be used to activate any type of alarm generator (bells, sirens, etc.), but these generators must be operated from their own power supplies, otherwise they may interfere with the electronic functioning of the actual alarm systems.

Also note that timing capacitor $C_2$ of the *Figure 2.2* and *2.3* circuits must have a reasonably low leakage, otherwise the alarms may fail to turn off at the end of their preset periods.

The circuits of *Figures 2.1* to *2.3* act as excellent burglar-alarm systems in their own right. Their capabilities can be considerably expanded, however, by adding on a few simple electronic accessories, as shown in the following section.

**Alarm-system accessory circuits**

A problem with all burglar-alarm systems is that of leaving or entering the house via a protected door once the system has been set into the 'standby' mode. A simple way around this problem is to fit a key-operated by-pass switch to the outside of the door, so that the door's sensor switch can be temporarily disabled by the authorised key holder.

In this case the procedure for leaving the house is first to open the door and disable its sensor via the key switch, then re-enter the house and set the alarm to 'standby', and then leave the house again, close the door and re-enable its sensor via the key switch. The procedure for re-entering the house without sounding the alarm is simply to disable the door sensor via the key switch, then enter the house and turn the alarm system off.

Most of the tedium of this procedure can be eliminated by equipping the alarm system with an 'exit delay' facility, which automatically disables the door sensor for a preset period after the main alarm system is switched to 'standby'. This facility enables the owner simply to

switch the alarm system to 'standby' and then leave the house without sounding the alarm, but it is still necessary for the owner to disable the door-sensor switch manually on re-entry if entry is to be made without sounding the alarm.

If required, even this re-entry procedure can be eliminated by equipping the alarm system with a combined 'exit and entry delay' facility. This ensures that the alarm will not sound until a preset time after the door sensor is initially activated by the entry action, thus giving the owner time to enter the house and turn off or reset the alarm system before the alarm actually sounds.

Practical 'exit delay' and 'exit and entry delay' circuits are shown in *Figures 2.4* and *2.5*. These facilities can readily be added to any of the main alarm-system circuits shown in *Figures 2.1* to *2.3*.

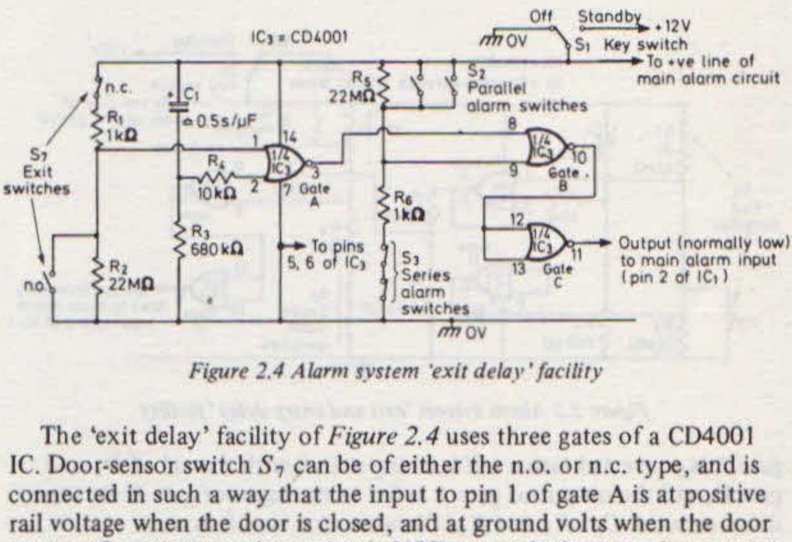



*Figure 2.4 Alarm system 'exit delay' facility*

The 'exit delay' facility of *Figure 2.4* uses three gates of a CD4001 IC. Door-sensor switch $S_7$ can be of either the n.o. or n.c. type, and is connected in such a way that the input to pin 1 of gate A is at positive rail voltage when the door is closed, and at ground volts when the door is open. Gate A is wired as a simple NOR gate, which gives a low output when either input is high, and time-delay network $C_1-R_3$ is connected to the pin 2 input of the gate via $R_4$. When power is first applied to the circuit $C_1$ is fully discharged, so pin 2 is effectively shorted to the positive supply line via $R_4$, and the output of the gate is at ground volts, irrespective of the state of the door sensor switch. After a delay determined by $C_1$ and $R_3$ (roughly 0.5 s/$\mu$F of $C_1$ value) the pin 2 voltage decays to such a value that the gate is influenced by the state of the door sensor switch. If the door is closed at this point the gate output remains low, but if the door is open the output goes high.

The output of gate A is taken directly to pin 8 of gate B, which is also connected as a NOR gate, and the main section of the alarm system's sensor circuitry is taken to pin 9 of this gate in such a way that this pin is effectively grounded under normal conditions. The output of gate B is inverted by gate C, which thus gives an output that is normally low, and this output is passed on directly to pin 2 of $IC_1$ in the main alarm circuit.

Thus, the action of the *Figure 2.4* circuit is such that all sensor switches except $S_7$ are enabled as soon as $S_1$ is set to the 'standby' position, and $S_7$ is disabled for a preset period. At the end of this period $S_7$ is enabled, and the alarm is able to respond to the actions of $S_7$.

The combined 'exit and entry delay' facility circuit of *Figure 2.5* is similar to that of *Figure 2.4*, except that $R_1$ is increased to 10 kΩ,

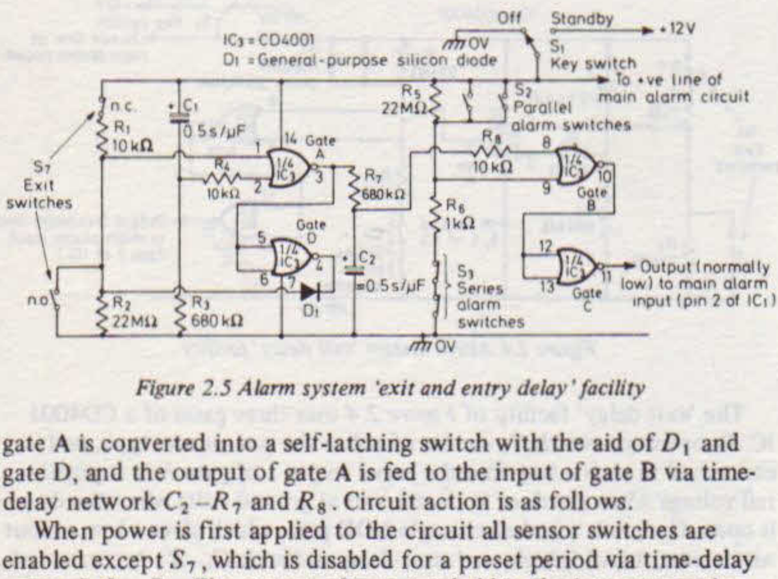



*Figure 2.5 Alarm system 'exit and entry delay' facility*

gate A is converted into a self-latching switch with the aid of $D_1$ and gate D, and the output of gate A is fed to the input of gate B via time-delay network $C_2-R_7$ and $R_8$. Circuit action is as follows.

When power is first applied to the circuit all sensor switches are enabled except $S_7$, which is disabled for a preset period via time-delay network $C_1-R_3$. The output of gate A is held in the low state under this condition. At the end of this preset period $S_7$ is enabled. If $S_7$ is activated after the end of this preset period, the output of gate A immediately goes high, and is locked in this state by the actions of $D_1$ and gate D. This high output voltage is applied to the input of gate B via time-delay network $C_2-R_7$, and after a preset delay (roughly equal to 0.5 s/μF of $C_2$ value) the voltage reaching gate B rises to such a value that the alarm is activated.

The circuit of *Figure 2.4* or *2.5* can be added to any of the main alarm circuits of *Figures 2.1* to *2.3* simply by removing the existing connections to pin 2 of $IC_1$, rewiring the existing alarm sensors into the *Figure 2.4* or *2.5* circuit, and connecting the outputs of this circuit to pin 2 of $IC_1$. Note that it is also necessary to wire the 'off' pin of key-switch $S_1$ to ground if a delay circuit is used, so as to provide a discharge path for its timing capacitors.

All the burglar alarm circuits shown in this chapter give reliable performances, and are not prone to giving false alarms under normal circumstances. One 'exceptional' circumstance which may initiate false alarms in any type of alarm system is a thunderstorm, where heavy electrical discharges may induce such large energy pulses into the alarm sensor wiring that the alarm is made to trigger falsely. In COS/MOS alarm systems this possibility can be eliminated by interposing 'sensor

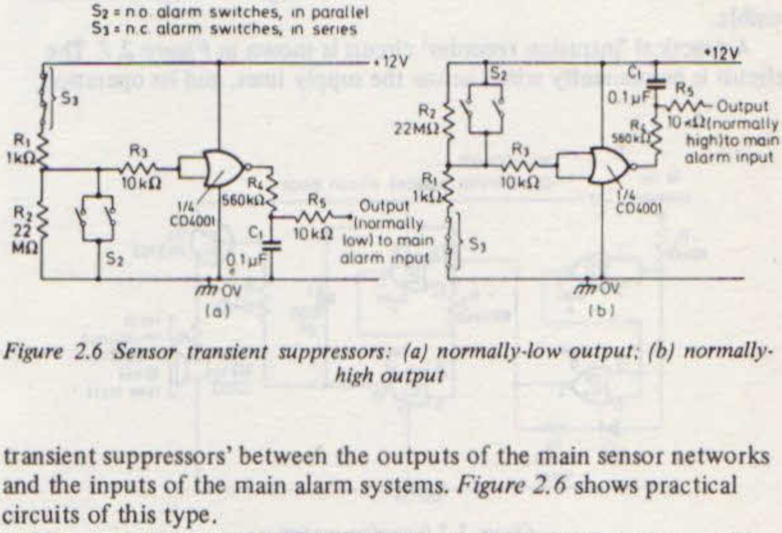



*Figure 2.6 Sensor transient suppressors: (a) normally-low output; (b) normally-high output*

transient suppressors' between the outputs of the main sensor networks and the inputs of the main alarm systems. *Figure 2.6* shows practical circuits of this type.

Here, a spare gate of a CD4001 IC is wired as a simple inverter, and the input of this gate is connected to the output of the main sensor network via limiting resistor $R_3$. The output of the gate is taken to the input of the main alarm via $R_5$ and time-constant network $C_1-R_4$. This network only passes signals that are applied to the gate input for periods greater than 50 ms. Consequently, the circuit rejects short-duration spurious pulses that are induced into the sensor wiring, but passes longer-duration signals that are generated by the activation of the sensor switches.

The *Figure 2.6a* circuit is intended for applications where the sensor input to the main alarm system is required to be normally low, and the *Figure 2.6b* circuit is for use where the sensor input needs to be normally high. In practice, these 'transient suppressor' circuits are only likely to be needed in cases where the lengths of alarm-sensor wiring exceed fifty metres or so, since all the alarm circuits shown in this chapter have fairly low input impedances (1 kΩ or 10 kΩ) when the sensor switches are in their normal states, and are thus not unduly sensitive to induced signals.

One final accessory that can be added to a burglar alarm system is an 'intrusion recorder'. This gadget is intended for use in auto-turn-off alarm systems only, and consists of a low-power sound generator that turns on and self-latches if an intrusion occurs, thus giving a continuous indication of the intrusion. The device can tell the owner that an intrusion has occurred during his absence from the house, even though the main alarm system has turned off and no signs of the intrusion are visible.

A practical 'intrusion recorder' circuit is shown in *Figure 2.7*. The circuit is permanently wired across the supply lines, and its operation

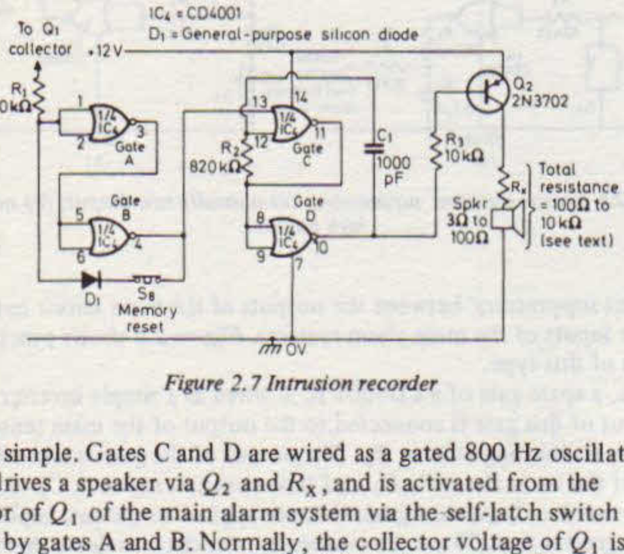



*Figure 2.7 Intrusion recorder*

is quite simple. Gates C and D are wired as a gated 800 Hz oscillator, which drives a speaker via $Q_2$ and $R_x$, and is activated from the collector of $Q_1$ of the main alarm system via the self-latch switch formed by gates A and B. Normally, the collector voltage of $Q_1$ is high and the alarm relay is off, and under this condition the 800 Hz oscillator is inoperative and the recorder circuit consumes a quiescent current of about 1 $\mu$A. If the main alarm system is activated the relay

turns on for a preset period and the collector of $Q_1$ goes high. Under this condition, gates A and B of the recorder turn on and self-latch, and activate the 800 Hz oscillator, thus causing an audible signal to be generated in the speaker. Once this signal has been initiated, it can only be stopped again by operating 'reset' switch $S_8$.

The *Figure 2.7* circuit can be added to the auto-turn-off circuit of *Figure 2.2* or *2.3* simply by wiring it across the supply lines and connecting $R_1$ to the collector of $Q_1$. The speaker used in the circuit can have any impedance in the range 3 Ω to 100 Ω. The combined series value of $R_x$ and the speaker impedance can be varied from a minimum value of 100 Ω up to 10 kΩ, depending on the sound level that is wanted from the speaker. The maximum power output of the circuit is about 250 mW when $R_x$ has a value of zero and a 100 Ω speaker is used, and in this case the circuit consumes roughly 50 mA of current. Proportionately lower currents are consumed at lower power levels.

**A comprehensive alarm system**

The alarm system accessory circuits of *Figures 2.4* to *2.7* can be added to the basic alarm circuits of *Figures 2.1* to *2.3* in any combination, depending on the requirements of the individual reader. The final alarm system can be as simple or as complex as the reader desires.

The comprehensive alarm system of *Figure 2.8* is shown as an example of how a number of different circuits can be wired together to meet a specific alarm system requirement. In this case the alarm is of the auto-turn-off type, has a 'panic' facility and an intrusion recorder, and is intended for use with an n.o. exit/entry switch. The system incorporates an 'exit and entry delay' facility, giving delays of about 25 seconds in each mode, and has transient suppression applied to the main sensor network. The system has provision for non-latch activation via n.o. heat-sensing switches, and thus also functions as an automatic fire alarm.

The 'panic' facility is designed around $IC_2$, and the intrusion recorder is designed around $IC_4$. Both of these sections of the circuit are permanently wired across the supply lines. The auto-turn-off operation is obtained via $IC_1$, and one of the spare gates of this IC is used to provide transient suppression for the main sensor network. Finally, $IC_3$ provides the 'exit and entry delay' facility. All four of the ICs used in the system are CD4001 types. Note that the 'off' terminal of key-switch $S_1$ is taken directly to ground, to provide a discharge path for the system's timing capacitors.

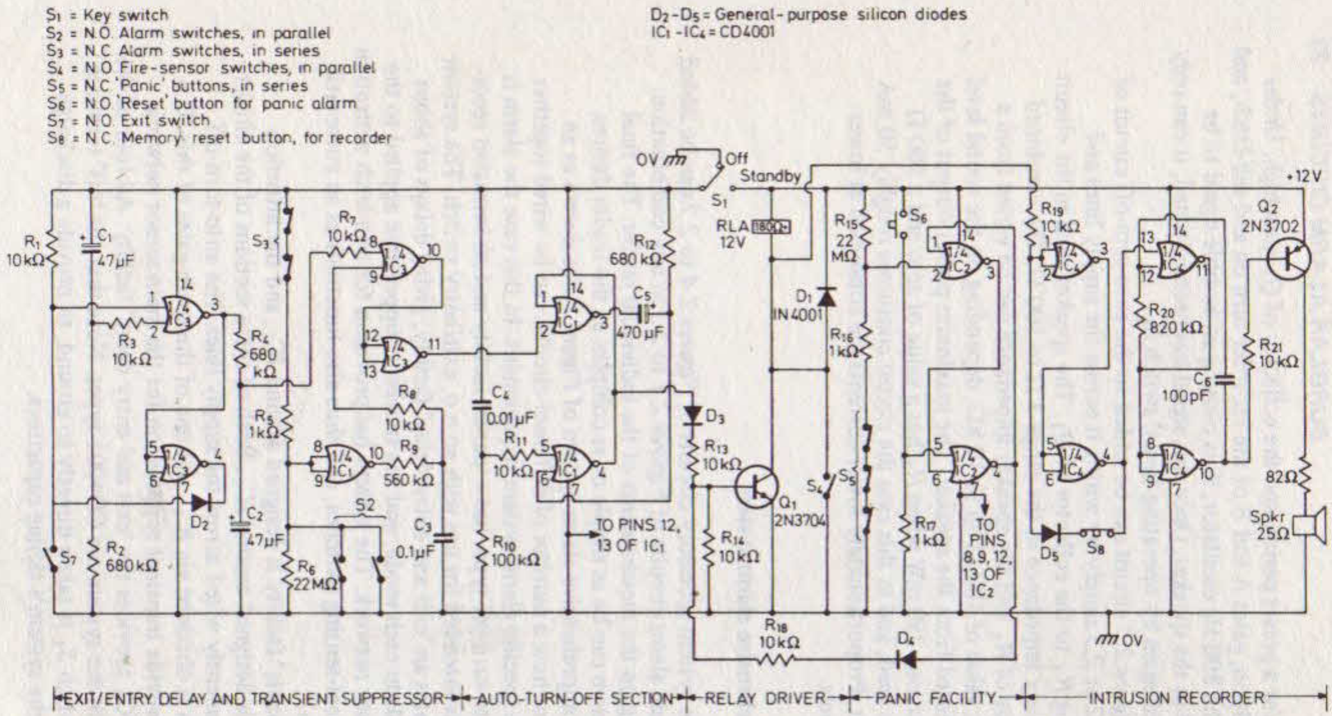



*Figure 2.8 Comprehensive alarm system*

**A utility burglar alarm system**

The burglar alarm circuits shown so far in this chapter are presented with the aim of enabling the reader to build an alarm system that meets his own specific requirements, which may be very simple or quite complex. By contrast, *Figure 2.9* shows the circuit of a utility burglar alarm that gives a very useful but restricted performance in home applications. Briefly, this circuit is designed for use with series-connected n.c. switches, and the alarm gives self-latching operation, so that once it is activated it continues to sound until it is turned off via a key-switch or its supply batteries run flat. The circuit action is such that an LED (light-emitting diode) illuminates if any of the n.c. sensor switches is open, but the actual alarm generator is automatically disabled for about 50 seconds when the circuit is first set to 'standby' via its key-switch. The actual alarm generator can use the same power supply as the *Figure 2.9* circuit, and the complete system can readily be modified to give 'fire' and 'panic' facilities.

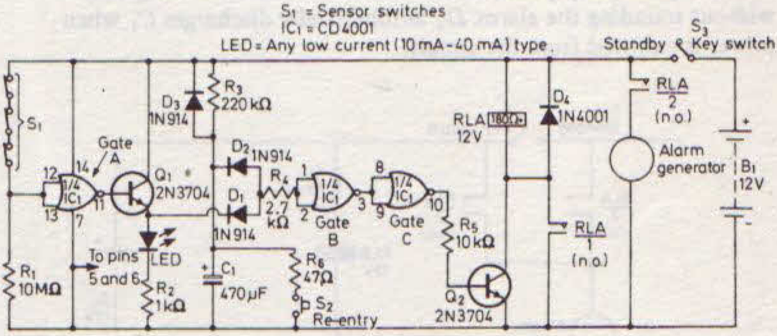



*Figure 2.9 Utility burglar alarm system*

In use, the alarm is first set to 'standby' via the key-switch, and the owner can then check by the LED that all sensor switches are correctly closed. The owner then has about 50 seconds in which he can leave the house without sounding the alarm. At the end of this period the whole alarm circuit becomes enabled, and if any of the sensor switches is subsequently opened the alarm generator activates and self-latches until the system is turned off manually or the supply batteries run flat. The owner can enter the house without activating the alarm by operating a simple push-button disabling switch fitted to the outside of the entry door.

The operation of the *Figure 2.9* circuit is quite simple. The series-connected n.c. sensor switches are taken to the input of gate A, which is used as a simple inverter, and the output of the inverter is taken to the LED via emitter-follower $Q_1$. The output of $Q_1$ is fed to relay-driving transistor $Q_2$ via a two-input diode AND gate formed by $D_1$ and $D_2$, and via gates B and C, which are connected as a non-inverting buffer stage. The other input of the AND gate is taken from the junction of the $R_3-C_1$ time-delay network; the action here is such that $C_1$ is fully discharged when power is first applied to the circuit, so gates B and C and transistor $Q_2$ are disabled, but after a delay of about 50 seconds $C_1$ charges to such a level that these components become enabled, and the relay operates if any of the input switches open and the LED goes on. The relay is made self-latching via the n.o. *RLA*/1 contacts, and the n.o. *RLA*/2 contacts are used to operate the alarm generator.

Note that the circuit can at any time be disabled for a period of about 50 seconds by briefly operating push-button switch $S_2$, so that it discharges $C_1$. In practice, $S_2$ can be concealed outside the house near the main entry point, so that the owner can enter the house without sounding the alarm. $D_3$ automatically discharges $C_1$ when power is removed from the circuit.

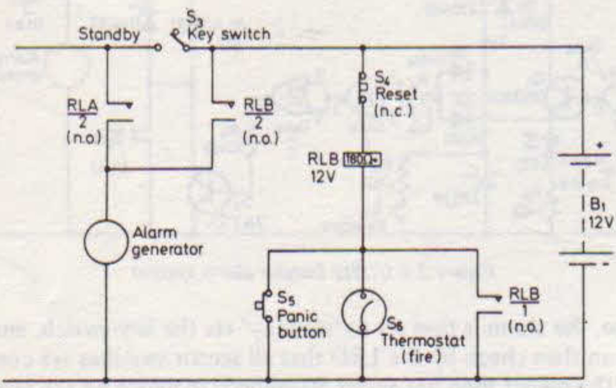



*Figure 2.10 Modification to Figure 2.9 circuit: 'fire' and 'panic' protection fitted*

Finally, *Figure 2.10* shows how an additional relay can be wired into the above circuit so that it also gives 'fire' and 'panic' protection. Here, n.c. push-button switch $S_4$ and the parallel-connected combination $S_5-S_6-RLB/1$ are all wired in series with relay B, and the

combination is permanently wired across the supply lines. The n.o. *RLB*/2 contacts are used to connect the alarm generator to the supply lines.

The circuit action is such that *RLB* is normally off, but the relay turns on and self-latches and activates the alarm generator if any of the $S_5$ or $S_6$ switches briefly close. Any number of n.o. 'panic' buttons can be wired in parallel with $S_5$, and any number of n.o. thermostats can be wired in parallel with $S_6$. Once *RLB* has turned on, it can be turned off again by briefly opening $S_4$, which may be located in a concealed position.

**10 W alarm-call generator circuits**

All the burglar alarm circuits shown in this chapter give relay outputs, which can be used to activate any type of alarm-call generator. They can be used to activate bells, sirens, or electronic generators that produce an output in a loudspeaker. Three suitable 10 W electronic generators are described in this section.

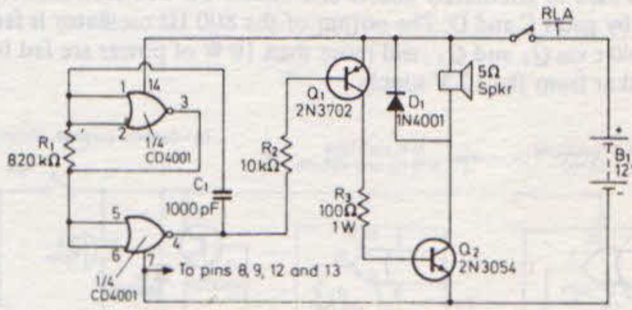



*Figure 2.11 Monotone 10 W alarm-call generator*

*Figure 2.11* shows the circuit of a simple 10 W monotone alarm-call generator. Here, two gates of a CD4001 IC are inter-connected as an 800 Hz square-wave generator. The output of the generator is fed to a 5 Ω speaker via a direct-coupled power amplifier stage formed by $Q_1$ and $Q_2$. The action of the circuit is such that the transistors are alternately switched from the fully off to the saturated state at a rate of 800 Hz, so the power losses of the circuit are low. More than 10 W of power are fed to the speaker from the 12 V supply. Note that the

two unused gates of the IC are disabled by wiring their input pins (pins 8, 9, 12 and 13) to pin 7.

*Figure 2.12* shows the circuit of a pulsed-tone alarm-call generator, which produces an 800 Hz tone that is pulsed on and off at a rate of

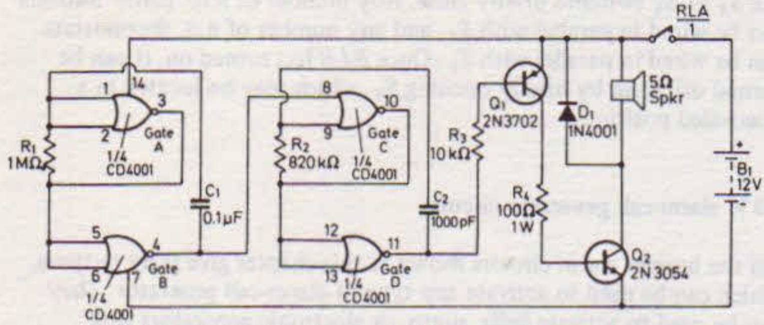



*Figure 2.12 Pulsed-output 10 W alarm-call generator*

6 Hz. Here, gates A and B are wired as a 6 Hz square-wave generator, which is used to alternately enable and disable the 800 Hz oscillator formed by gates C and D. The output of the 800 Hz oscillator is fed to the speaker via $Q_1$ and $Q_2$, and more than 10 W of power are fed to the speaker from the 12 V supply.

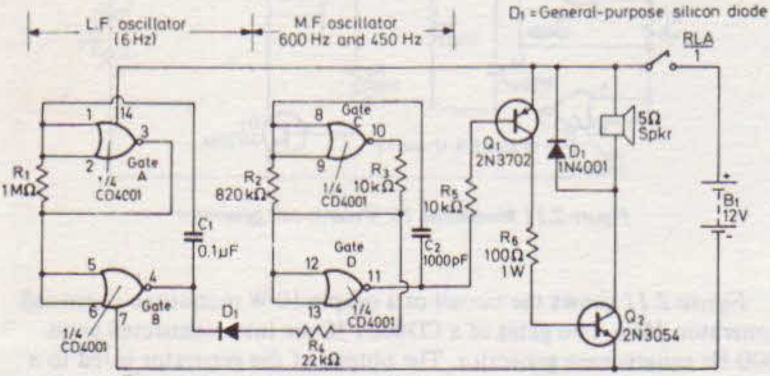



*Figure 2.13 Warble-tone 10 W alarm-call generator*

Finally, *Figure 2.13* shows the connections for making a warble-tone generator, in which the output switches alternately between 600 Hz and 450 Hz at a rate of 6 Hz. Here, the 6 Hz oscillator formed by gates

A and B is used to vary the periods and thus the frequency of the oscillator formed by gates C and D. The output of the IC is fed to the speaker via $Q_1$ and $Q_2$, and the output power of the circuit is greater than 10 W.

Note that the alarm-call generator circuits of *Figures 2.11* to *2.13* each use a 12 V battery supply. Also note that each circuit uses a 5 Ω speaker, and that a damping diode is wired across this speaker to suppress unwanted back e.m.f.s.

Each alarm-call generator circuit can be activated from the main alarm system by wiring the alarm's n.o. *RLA* contacts in series with the generator's positive supply lines, as shown in the diagrams. Note that, except in the case of *Figure 2.9,* the generator must use supplies that are independent of those of the main alarm system.

**Alarm sensor systems**

All the alarm circuits described in this chapter are 'contact operated' types. They are activated by the making or breaking of electrical contacts that are built into simple 'sensor' devices. These sensors can take the form of microswitches or reed-relays that are activated by the opening of a door or window, or of pressure pads that close when a person treads on a rug or carpet, or of lengths of wire or foil that break when a person forces an entry through a window, wall, floor or ceiling.

The selection of a complete alarm sensor installation depends on a number of factors. Amongst these are the physical details of the building that is to be protected, the value of the goods that are to be protected, and the ideas on crime prevention of the individual property owner. The choice of an installation is a very personal matter; the following notes are given to help the reader make that choice.

Any building can, for crime prevention purposes, be regarded as a box that forms an enclosing perimeter around a number of interconnected compartments. This perimeter 'box' is the shell of the building, and contains walls, floors, ceilings, doors and windows. To commit any crime within the building, the intruder must break through this perimeter, which thus forms the owner's first line of defence.

Once an intruder has entered the building, he can move from one room or 'compartment' to the next only along paths that are predetermined by the layout of internal doors and passages. In moving from one compartment to the next he must inevitably pass over certain 'spots' in the building, as is made clear in *Figure 2.14,* which shows the ground-floor plan of a small house. Thus to move between the lounge

and the hall he must pass over spot $X_1$, to move between the kitchen and the hall he would tend to pass over spot $X_2$, and to move from the ground floor to the upper floor he must pass over spot $X_3$. These 'spot' points form the owner's second line of defence.

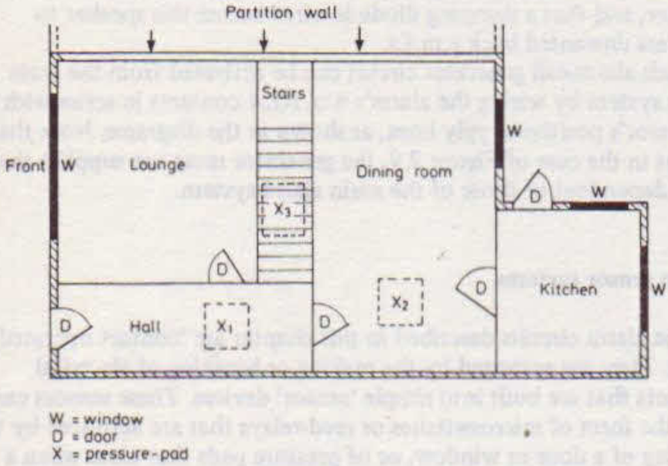



*Figure 2.14 Ground-floor plan of small house, showing suitable positions for pressure-pad 'spot' defences*

Thus the owner can obtain protection by using full or partial 'perimeter' defence, or by using 'spot' defence, or by using a combination of the two methods.

The most expensive type of alarm-sensor installation that can be fitted is the full perimeter defence system, which includes series-connected sensor wires built into all walls, floors and ceilings, as well as microswitches or reed-relays on all doors and windows. This type of installation is normally fitted only to commercial buildings such as jewelry stores or lock-up shops, etc., where the risk of burglary by skilful intruders is very high.

The least expensive type of alarm-sensor installation is the spot defence system, which can consist of just two or three pressure pads wired in parallel and hidden under rugs or carpets. This type of installation is adequate where the risk of burglary is small and the value of the protected goods is fairly low.

Intermediately priced partial perimeter defence installations can range from something as simple as a microswitch on a single side or rear door, to something that includes microswitches or reed-relays on

all doors and window frames, plus protective foil on all windows and skylights. These systems can give adequate protection against most amateur and professional burglars, particularly when the installation is coupled to a spot defence system.

Burglars can, in general terms, be described as being of three basic types. The most common is the novice or amateur burglar, who enters a house at random in the hope of finding items worth stealing. This type of intruder usually has insufficient skill or motivation to beat even the simplest detector devices, and will flee at the first sound of an alarm bell.

The second type of intruder is the small-time professional. This type of burglar breaks into a house only if he is sure that it contains valuable items. Before attempting to enter a house he makes a thorough reconnaissance of its defence systems, and commits the actual burglary only if he thinks he has found an unprotected entry point, such as a skylight or an accessible ceiling or floor. He may be so 'cool' that he will ignore an alarm bell for several minutes before fleeing. The best defence against this type of intruder is a carefully thought out partial perimeter system, combined with a few 'spot' defence points.

Finally, the most difficult burglar to beat is the organised or gang professional, who plays for high stakes and will go to great lengths to win. He may be willing to simply crash his way through a defence wall, or hurt anyone that gets in his way. He may be undeterred by the sound of an alarm. The most effective defence against this type of criminal is a multiple perimeter system, in which the main building is surrounded by a partially protected outer perimeter, such as a wall, and all valuables are held within a fully protected inner perimeter, such as a strong-room.

Note that all alarm systems should, ideally, be fitted with a panic facility, to enable the owner to summon aid if an intrusion occurs while he is on the premises.

Different crime-prevention authorities have different ideas on the best way to protect a home against burglary. Some claim that every effort should be made to keep burglars out of the house at the outset, and that all possible points of entry should be protected. Others claim that a determined and skilful burglar can get past all but the most comprehensive of perimeter defence systems, so the most sensible approach is to have a very simple partial perimeter defence system combined with a good spot defence network, so that an intruder can enter the premises with relative ease but is scared off as soon as he gets inside.

Thus there are many points to consider when selecting a sensor system, and the reader must make up his own mind as to the best system to use in his particular case. Once the sensor system has been

selected, the layout of the full alarm system installation must be considered. The following notes should be of value in this respect.

**Alarm system installations**

*Figure 2.15* shows how a full alarm system installation can be broken down into three basic 'blocks', namely the sensor network, a control centre, and the alarm-call generator. The layout of the sensor network has already been discussed, and is a matter for individual decision.

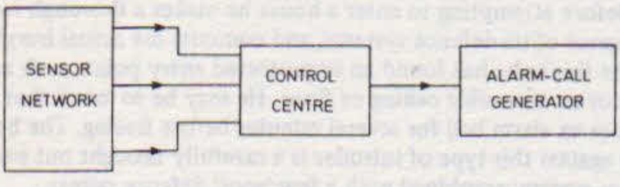



*Figure 2.15 Block diagram of practical alarm-system installation*

The alarm-call generator can be mounted in a prominent position on the front of the building, to act as a deterrent to would-be burglars, or it can be concealed in the eaves of the house in such a position that it can be heard equally well inside and outside the building. In either instance, the generator and its battery supply should be housed in a strong, burglar-proof box, and connected to the control centre either via an armoured cable or via cable that is concealed in the plasterwork, etc.

The control centre contains the electronics of the alarm system, together with the system's supply battery, plus a number of switches that enable different parts of the system to be turned on or off or to be tested. The centre should ideally be housed in a burglar-proof box, and the connections to the sensors should be made via armoured cable or concealed wiring.

*Figure 2.16* shows a typical control-centre instrument panel, with five control switches. Switch $S_1$ is the main alarm system's 'on/off' control. As mentioned earlier, certain sections of the alarm system (such as fire sensors and panic facilities) must be permanently enabled, so $S_1$ controls the burglar alarm section of the circuit only. $S_2$ enables any auxiliary sensor devices, such as flood, overheat or power-failure detectors, to be switched in or out of the alarm system. Switches $S_3$ to

$S_5$ enable individual sections of the burglar-alarm sensor system, such as front door, stair or garage defences, to be connected or disconnected from the circuit.

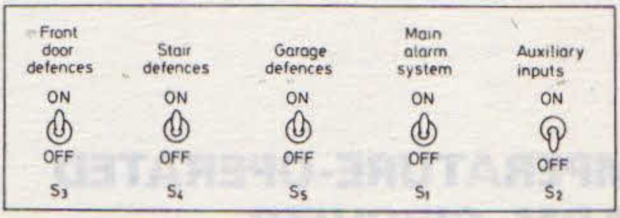



*Figure 2.16 Typical control-centre instrument panel*

Finally, *Figure 2.17* shows the connections for turning individual sections of the alarm sensor network on and off. Series-connected n.c. sensor networks can be enabled or disabled by wiring them in parallel with $S_1$, as shown in *Figure 2.17a.* The sensors are enabled when $S_1$ is

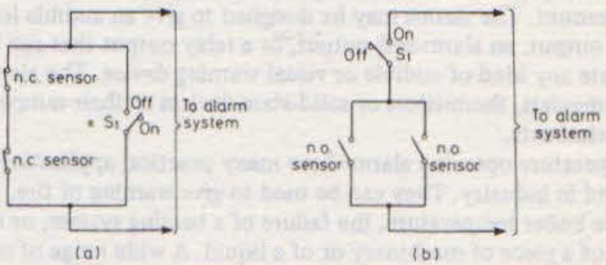



*Figure 2.17 Method of enabling and disabling sensors via* $S_1$ *: (a) series-connected, n.c., (b) parallel-connected, n.o.*

open, and are disabled when $S_1$ is closed. Parallel-connected n.o. sensor networks can be enabled and disabled by wiring them in series with $S_1$, as shown in *Figure 2.17b.* The sensors are enabled when $S_1$ is closed, and are disabled when $S_1$ is open.

CHAPTER 3

# TEMPERATURE-OPERATED ALARM CIRCUITS

Temperature-operated alarms can be used as automatic fire or overheat alarms, as frost or underheat alarms, or as differential temperature alarms that operate when two temperatures differ by more than a preset amount. The alarms may be designed to give an audible loudspeaker output, an alarm-bell output, or a relay output that can be used to operate any kind of audible or visual warning device. The alarms may use thermostats, thermistors or solid-state devices as their temperature-sensing elements.

Temperature-operated alarms have many practical applications in the home and in industry. They can be used to give warning of fire, frost, excessive boiler temperature, the failure of a heating system, or overheating of a piece of machinery or of a liquid. A wide range of useful alarm types are described in this chapter.

## Thermostat fire-alarm circuits

One of the simplest types of temperature-operated alarm is the thermostat-activated fire alarm. *Figure 3.1* shows the practical circuit of a relay-aided non-latching alarm of this type. Here, a number of n.o. thermostats are wired in parallel and then connected in series with the coil of a relay, and one set of the relay's n.o. contacts are wired in series with the alarm bell so that the bell operates when the relay turns on.

Normally, the thermostats are all open, so the relay and the alarm bell are off. Under this condition the circuit consumes zero standby current. At 'overheat' temperatures, on the other hand, one or more of the thermostats closes, and thus turns on the relay and thence the alarm bell. Note that push-button switch $S_1$ is wired in parallel with the thermostats, so that the circuit can be functionally tested by operating the push-button.

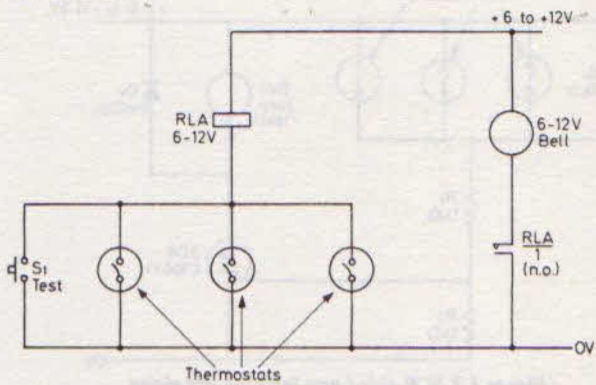



*Figure 3.1 Simple relay-aided non-latching fire alarm*

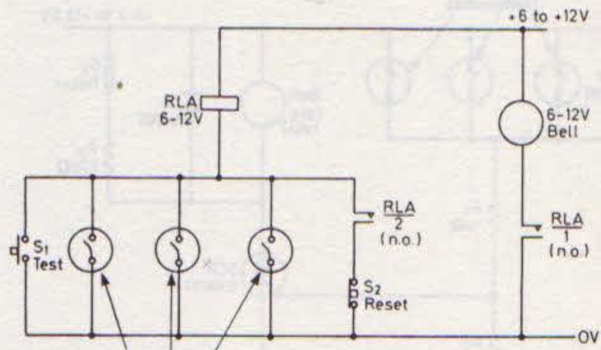



*Figure 3.2 Simple relay-aided self-latching fire alarm*

The thermostats used in this and all other circuits described here must be n.o. types that close when the temperature exceeds a preset limit. When the thermostats are located in normal living areas they should be set to close at a temperature of roughly 60°C (140°F), but when they are located in unusually warm places, such as furnace rooms or attics, they should be set to close at about 90°C (194°F).

The basic *Figure 3.1* circuit gives a non-latching form of operation. If required, the circuit can be made self-latching by wiring a spare set of n.o. relay contacts in parallel with the thermostats, as shown in *Figure 3.2.* Note that n.c. push-button switch $S_2$ is wired in series with the relay contacts, so that the circuit can be reset or unlatched by momentarily operating $S_2$.

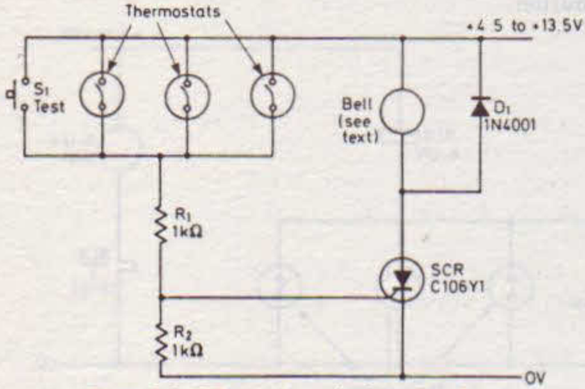



*Figure 3.3 SCR-aided non-latching fire alarm*

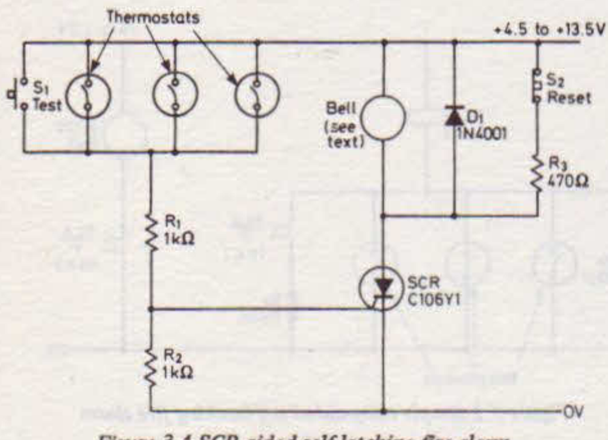



*Figure 3.4 SCR-aided self-latching fire alarm*

Bell-output fire-alarms can sometimes be activated via an SCR rather than a relay; *Figure 3.3* shows a typical circuit of this type. Here, a self-interrupting type of alarm bell is wired in series with the SCR anode, and gate current is provided from the positive supply line via the thermostats and via current-limiting resistor $R_1$. Normally the thermostats are

open, so the SCR and the bell are off, and the circuit passes only a small leakage current. At high temperatures the thermostats close, so gate current is applied via $R_1$, and the SCR and the alarm bell turn on.

The basic *Figure 3.3* circuit gives a non-latching form of operation. The circuit can be made self-latching by wiring shunt resistor $R_3$ across the bell as shown in *Figure 3.4,* so that the SCR current does not fall below its latching value when the bell goes into its self-interrupting mode. Note that push-button switch $S_2$ is wired in series with $R_3$ so that the circuit can be reset or unlatched.

It should be noted that the SCR used in the *Figure 3.3* and *3.4* circuits has a current rating of only 2 A, so the alarm bell should be selected with this point in mind. Alternatively, SCRs with higher current ratings can be used in place of the device shown, but this modification may also necessitate changes in the $R_1$ and $R_3$ values of the circuits.

Thermostat fire alarms can be made to generate an alarm signal directly into a loudspeaker by using the connections of *Figure 3.5* or *3.6.* The *Figure 3.5* circuit generates a pulsed-tone non-latching alarm signal, while the *Figure 3.6* circuit generates an 800 Hz (monotone) self-latching alarm signal. Both are designed around a CD4001 COS/MOS digital IC.

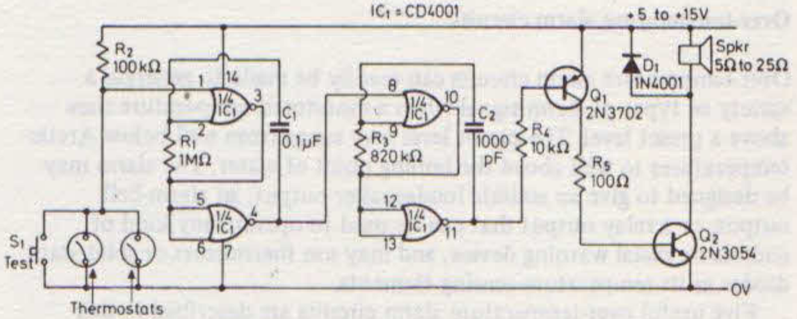



*Figure 3.5 800 Hz pulsed-output non-latching fire alarm*

The *Figure 3.5* circuit, which gives an output tone of 800 Hz pulsed on and off at a rate of 6 Hz, is based on the circuit of *Figure 1.11a* combined with a medium-power output stage. A full description of the circuit operation is given in Chapter 1.

The *Figure 3.6* self-latching circuit, which gives an 800 Hz monotone output, is based on the circuit of *Figure 1.14a* combined with a medium-power output stage. A full description of the operation of this circuit is also given in Chapter 1.

The circuits of *Figures 3.5* and *3.6* can be used with any supply voltages in the range 5–15 V, and with any speaker impedances in the range 5–25 Ω. The actual output power of each circuit depends on the

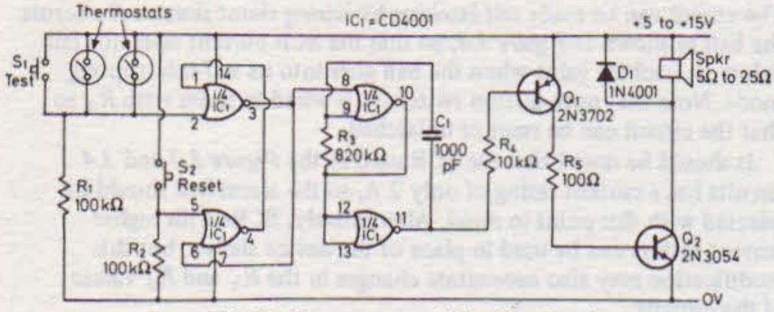


*Figure 3.6 800 Hz monotone self-latching fire alarm*

values of supply voltage and speaker impedance that are used, and varies from 0.25 W when a 25 Ω speaker is used with a 5 V supply, to 11.25 W when a 5 Ω speaker is used with a 15 V supply.

**Over-temperature alarm circuits**

Over-temperature alarm circuits can readily be made to generate a variety of types of alarm signal when a monitored temperature rises above a preset level. The preset level may range from well below Arctic temperatures to well above the boiling point of water. The alarm may be designed to give an audible loudspeaker output, an alarm-bell output, or a relay output that can be used to operate any kind of audible or visual warning device, and may use thermistors or solid-state diodes as its temperature-sensing elements.

Five useful over-temperature alarm circuits are described in this section. Most of them use inexpensive negative temperature coefficient (n.t.c.) thermistors as their temperature-sensing elements. These devices act as temperature-sensitive resistors that present a high resistance at low temperatures and a low resistance at high temperatures.

The thermistor circuits described in this and the following sections of this chapter have all been designed to work with thermistors that present a resistance of roughly 5 kΩ at the desired operating temperature. All these circuits are highly versatile, however, and will work well with any n.t.c. thermistors that present a resistance in the range 1 kΩ to 20 kΩ at the required temperature.

*Figure 3.7* shows the practical circuit of a simple but highly efficient over-temperature alarm that gives a relay output. Here, the thermistor and $R_1$–$R_2$–$R_3$ are wired in the form of a simple bridge, in which $R_1$ is adjusted so that the bridge is almost balanced at the desired operating temperature, and a type 741 operational amplifier and transistor $Q_1$ are used as the bridge balance detector and relay driver.

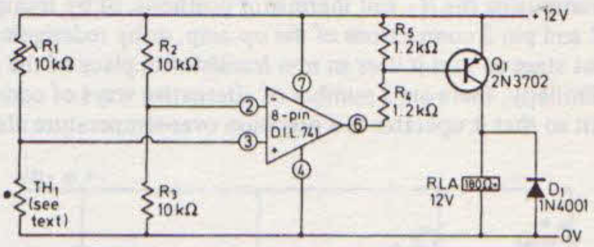



*Figure 3.7 Relay-output precision over-temperature alarm*

The 741 op-amp is used in the open-loop mode in the *Figure 3.7* circuit, and the device characteristics under this condition are such that its output (at pin 6) is driven to negative saturation (i.e. goes to almost zero volts) if its inverting (pin 2) input is more than a few millivolts positive to the non-inverting (pin 3) input, and is driven to positive saturation (i.e. goes to almost full positive-rail voltage) if its inverting input is more than a few millivolts negative to the non-inverting input. Thus when the bridge of the *Figure 3.7* circuit is close to balance, the op-amp can be driven from full positive saturation to full negative saturation, and vice versa, by pin 2 to pin 3 differential voltage changes of only a few millivolts.

Suppose, then, that the bridge is adjusted so that it is close to balance at the desired 'alarm' temperature. When the temperature falls below this value, the resistance of the thermistor increases, so the voltage on pin 3 of the op-amp rises above that of pin 2. Consequently, since pin 2 is negative to pin 3, the op-amp goes to positive saturation and applies zero base drive to $Q_1$, so $Q_1$ and the relay are off under this condition.

When, on the other hand, the temperature rises above the preset 'alarm' value, the resistance of the thermistor falls and the voltage on pin 3 of the op-amp falls. Consequently, since pin 2 is positive to pin 3, the op-amp goes to negative saturation and applies heavy base drive to $Q_1$, so $Q_1$ and the relay are driven on under this condition. Thus the relay goes on when the temperature rises above the preset level, and turns off when the temperature falls below the preset level.

Important points to note about the *Figure 3.7* circuit are that, because of the bridge configuration used, its accuracy is independent of variations in supply voltage, and that the alarm is capable of responding to resistance changes of less than 0.1 per cent in the thermistor, i.e. to temperature changes of a fraction of a degree.

Another point to note is that the circuit is quite versatile. It can, for example, be converted to a precision under-temperature alarm by simply transposing the $R_1$ and thermistor positions, or by transposing the pin 2 and pin 3 connections of the op-amp, or by redesigning the $Q_1$ output stage so that it uses an npn transistor in place of the pnp device. Similarly, there are a number of alternative ways of connecting the circuit so that it operates as a precision over-temperature alarm.

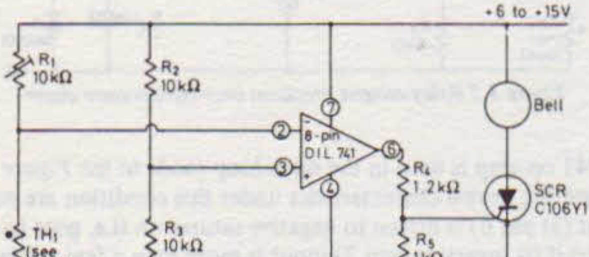



*Figure 3.8 Direct-output precision over-temperature alarm*

One such alternative, shown in *Figure 3.8*, provides a precision over-temperature alarm with an alarm-bell output. The circuit is similar to that of *Figure 3.7*, except that the pin 2 and pin 3 connections of the op-amp are transposed, and the output of the op-amp is used to drive the gate of an SCR rather than the base of a pnp transistor. The circuit action is such that the op-amp goes to negative saturation at 'low' temperatures, so zero drive is applied to the SCR gate and the SCR and the alarm bell are both off, but the op-amp goes to positive saturation at 'high' temperatures and thus drives the SCR and the alarm bell on. The SCR specified in the circuit has a mean current rating of only 2 A, so the alarm bell (a self-interrupting type) must be selected with this point in mind.

The two temperature-alarm circuits that we have looked at so far are designed to use thermistors with nominal resistances of 5 kΩ as their temperature-sensing elements, and these thermistors dissipate several milliwatts of power under working conditions. In some special applications this power dissipation may cause enough self-heating of the thermistor to upset the thermal sensing capability of the device. In

such cases an alternative type of temperature-sensing device may have to be used.

Ordinary silicon diodes have temperature-dependent forward volt-drop characteristics, and can thus be used as temperature-sensing elements. Typically, a silicon diode gives a forward volt drop of about 600 mV at a current of 1 mA. If this current is held constant, the volt drop changes by about –2 mV for each degree centigrade increase in diode temperature. All silicon diodes have similar thermal characteristics. Since the power dissipation of the diode is a mere 0.6 mW under the above condition, negligible self-heating takes place in the device, which can thus be used as an accurate temperature sensor.

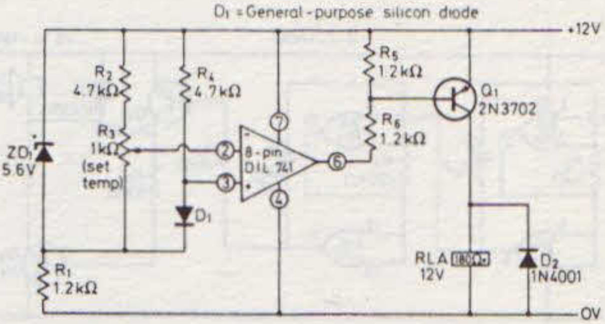



*Figure 3.9 Relay-output over-temperature alarm using silicon-diode temperature sensing element*

*Figure 3.9* shows how a general-purpose silicon diode can be used as a thermal sensing element in an op-amp over-temperature alarm circuit. Here, zener diode $ZD_1$ is wired in series with $R_1$ so that a constant 5.6 V is developed across the two potential dividers formed by $R_2-R_3$ and $R_4-D_1$. A virtually constant current thus flows in each of these dividers. A constant reference voltage is thus developed between the $R_1-R_3$ junction and pin 2 of the op-amp, and a temperature-dependent voltage with a coefficient of $-2$ mV/°C is developed between the $R_1-R_3$ junction and pin 3 of the op-amp. Thus a differential voltage with a coefficient of $-2$ mV/°C appears between pins 2 and 3 of the op-amp.

In practice this circuit is set up by simply raising the temperature of $D_1$ to the required over-temperature trip level, and then slowly adjusting $R_3$ so that the relay just turns on. Under this condition a differential temperature of about 1 mV appears between pins 2 and 3 of the op-amp, the pin 3 voltage being below that of pin 2, and $Q_1$ and the relay are driven on. When the temperature falls below the trip level, the

pin 3 voltage rises above that of pin 2 by about 2 mV/°C change in temperature, so $Q_1$ and the relay turn off. The circuit has a typical sensitivity of about 0.5°C, and can be used as an over-temperature alarm at temperatures ranging from sub-zero to above the boiling point of water.

It should be noted that the operation of the circuit can be reversed, so that it works as an under-temperature alarm, by simply transposing the pin 2 and pin 3 connections of the op-amp.

Finally in this section, *Figures 3.10* and *3.11* show the circuits of a pair of over-temperature alarms that give alarm outputs directly into loudspeakers. The *Figure 3.10* circuit generates a pulsed-tone alarm

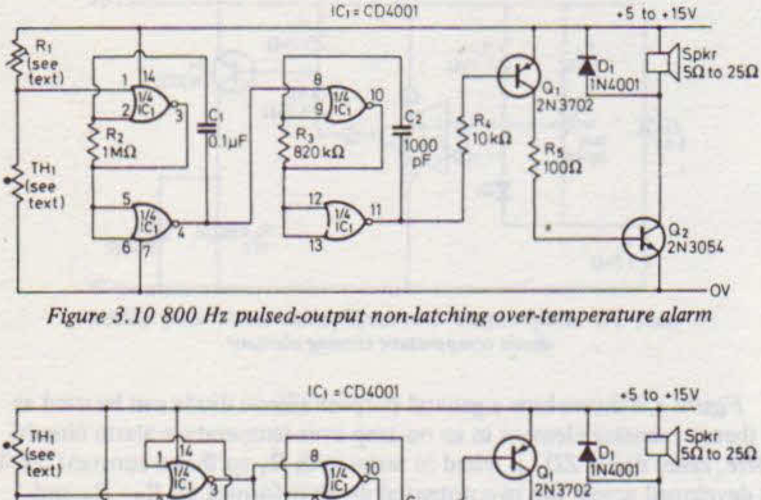



*Figure 3.10 800 Hz pulsed-output non-latching over-temperature alarm*

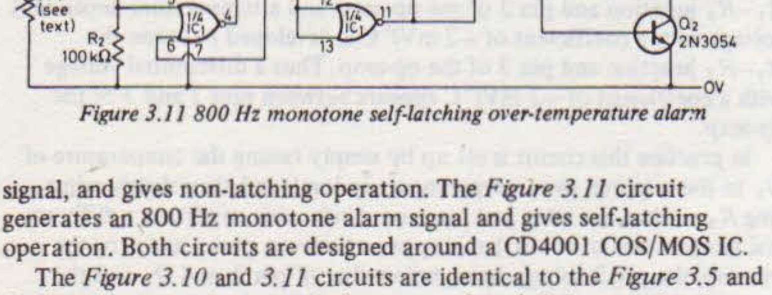



*Figure 3.11 800 Hz monotone self-latching over-temperature alarm*

signal, and gives non-latching operation. The *Figure 3.11* circuit generates an 800 Hz monotone alarm signal and gives self-latching operation. Both circuits are designed around a CD4001 COS/MOS IC.

The *Figure 3.10* and *3.11* circuits are identical to the *Figure 3.5* and *3.6* fire-alarm circuits respectively, except that their input activating

signals are taken from the junction of the $R_1 - TH_1$ potential divider rather than from the contacts of the thermostats.

An inherent feature of the *Figure 3.10* and *3.11* COS/MOS circuits is that they become enabled or disabled when their input activating voltages rise above or fall below a precisely defined 'threshold' value. This threshold voltage is not a fixed value, but is equal to a fixed percentage of the circuit's supply voltage, as in the case of a resistive potential divider. Consequently, these circuits switch from a disabled to an enabled state, or vice versa, when the $R_1 - TH_1$ ratios go above or below a precisely defined value. This ratio is independent of the supply voltage, but is dependent on the threshold value of the individual CD4001 IC that is used in each circuit. The ratio has a nominal value of 50:50, but in practice may vary from 30:70 to 70:30 between individual ICs.

What the above paragraph means in practice is that the *Figure 3.10* and *3.11* circuits each turn on when their temperatures exceed a value that is preset by $R_1$. The circuits have typical sensitivities of about 0.5°C.

The basic *Figure 3.10* and *3.11* circuits can be used with any supply voltages in the range 5–15 V, and with speaker impedances in the range 5–25 Ω. The circuits give output powers in the range 0.25 W to 11.25 W, depending on the values of impedance and voltage that are used.

## Under-temperature alarm circuits

The over-temperature alarm circuits of *Figures 3.7* to *3.11* can all be converted to give under-temperature alarm operation by making very simple alterations to their input connections, as shown in *Figures 3.12* to *3.16*.

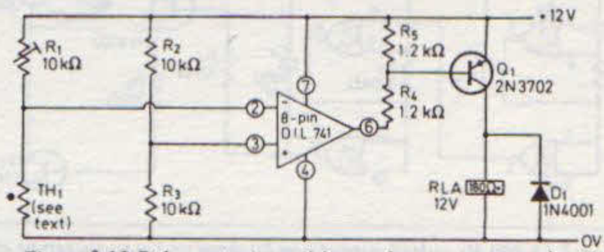



*Figure 3.12 Relay-output precision under-temperature alarm*

*Figures 3.12* to *3.14* show how the circuits of *Figures 3.7* to *3.9* can be converted to under-temperature alarm operation by simply transposing the connections of pins 2 and 3 of their op-amps. *Figures 3.15*

and *3.16* show how the circuits of *Figures 3.10* and *3.11* can be converted to under-temperature alarms by simply transposing their $R_1$ and $TH_1$ positions.

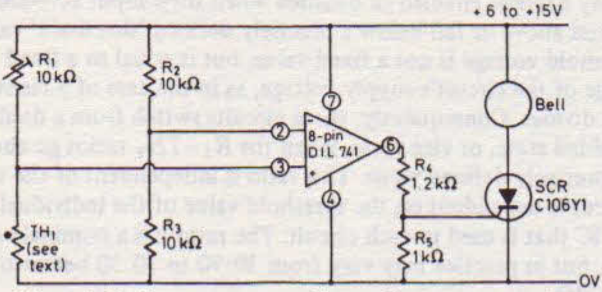



*Figure 3.13 Direct-output precision under-temperature alarm*

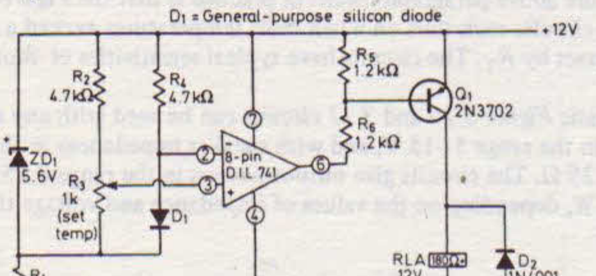



*Figure 3.14 Relay-output under-temperature alarm using silicon-diode temperature sensing element*

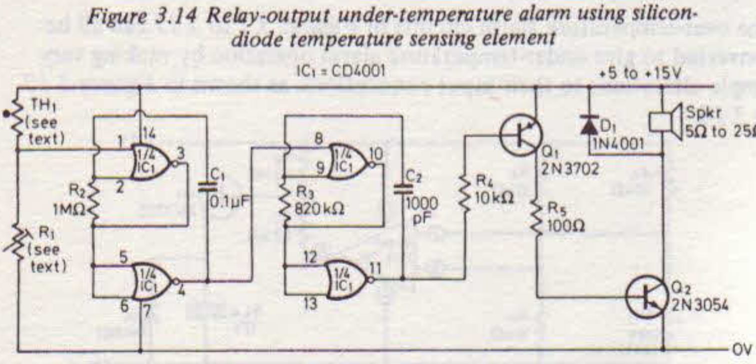



*Figure 3.15 800 Hz pulsed-output non-latching under-temperature alarm*

As a point of general interest, it may be noted that temperature alarms are normally used in the non-latching mode, so that the alarms are always off when the monitored temperature is within its preset limits. All the circuits of *Figures 3.7* to *3.15*, except *Figure 3.11*, are

designed to give this kind of operation. If required, the circuits of *Figures 3.7, 3.9, 3.12* and *3.14* can each be made self-latching by wiring a spare set of n.o. relay contacts between the emitter and

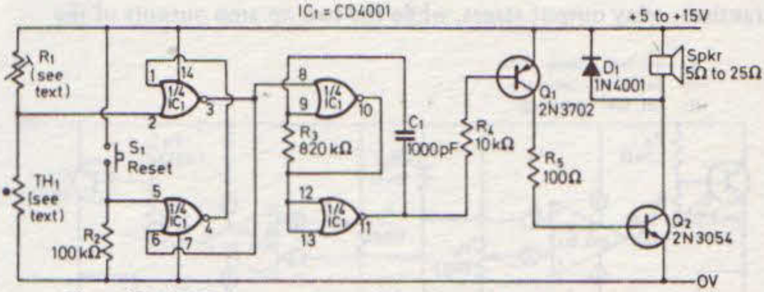



*Figure 3.16 800 Hz monotone self-latching under-temperature alarm*

collector of $Q_1$, and the circuits of *Figures 3.8* and *3.13* can each be made self-latching by wiring a 470 Ω resistor in parallel with the alarm bell.

## Miscellaneous temperature alarms

The temperature alarm circuits that we have looked at so far are all designed to indicate an alarm condition when the temperature either goes above or below a preset level. In this final section of the chapter we show three other types of temperature-alarm system. Two of these systems are designed to indicate an alarm condition if the temperature deviates from a preset level by more than a preset amount, and the third system gives an alarm indication if two monitored temperatures differ by more than a preset amount. All three alarm systems are designed to give a relay output, which can be used to operate any type of audible or visual alarm device.

*Figures 3.17* and *3.18* show the circuits of a pair of temperature-deviation alarms, which give an alarm indication if the temperature deviates from a preset level by more than a preset amount. The *Figure 3.17* circuit has independent over-temperature and under-temperature relay outputs, while the *Figure 3.18* circuit has a single relay output that activates if the temperature goes above or below preset levels.

Both circuits are made by combining the basic over-temperature and under-temperature circuits of *Figures 3.7* and *3.12.* The right (over-temperature) half of each circuit is based on that of *Figure 3.7,* and the left (under-temperature) half is based on that of *Figure 3.12.* Both

halves of the circuit share a common $R_1$–$TH_1$ temperature-sensing network, but the under-temperature and over-temperature switching levels of the circuits are independently adjustable. Each of the two op-amp outputs of the *Figure 3.17* circuit is taken to independent transistor-relay output stages, while the two op-amp outputs of the

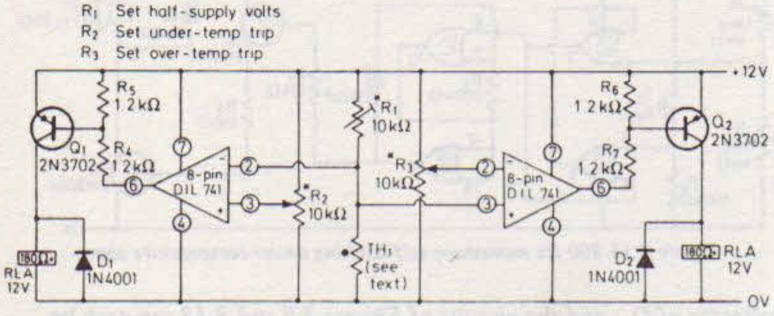



*Figure 3.17 Temperature-deviation alarm with independent over/under-temperature relay outputs*

*Figure 3.18* circuit are taken to a single transistor-relay output stage via the $D_1$–$D_2$ gate network. The procedure for setting up the two circuits is as follows.

First set $R_2$ and $R_3$ to roughly mid-travel; then, with the thermistor at its normal or mid-band temperature, adjust $R_1$ so that half-supply

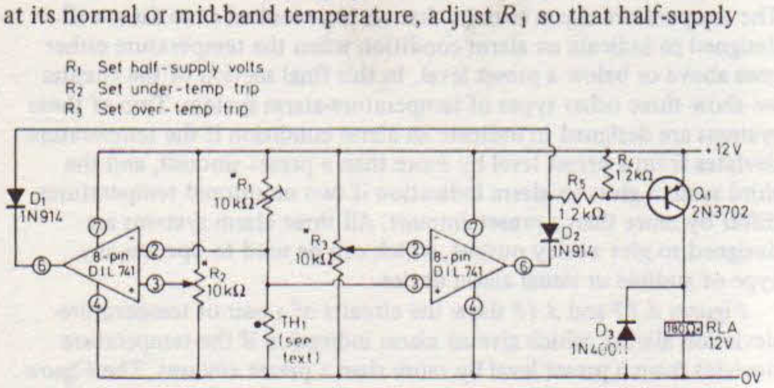



*Figure 3.18 Temperature-deviation alarm with single relay output*

volts are developed across $TH_1$. Now fully rotate the $R_2$ slider towards the positive supply line, rotate the $R_3$ slider towards the zero volts line, and check that no alarm condition is indicated (relays off). Next, reduce the $TH_1$ temperature to the required under-temperature trip level, and adjust $R_2$ so that the appropriate relay goes on to indicate

an alarm condition. Now increase the temperature slightly, and check that the relay goes off. Finally, increase the temperature to the required over-temperature trip level, and adjust $R_3$ so that the appropriate relay goes on to indicate the alarm condition. All adjustments are then complete, and the circuits are ready for use.

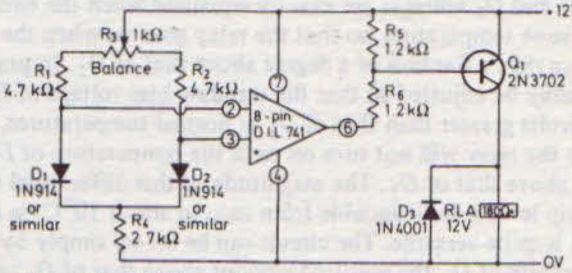



*Figure 3.19 Differential-temperature alarm, relay output*

Finally, to complete this chapter, *Figure 3.19* shows how a pair of silicon diodes can be used as temperature-sensing elements in a differential-temperature switch, which turns on only when the temperature of $D_1$ is more than a preset amount greater than that of $D_2$, and is not influenced by the absolute temperature of the two diodes. Circuit operation is as follows.

$D_1$ and $D_2$ are general-purpose silicon diodes, and are used as temperature-sensing elements. A standing current can be passed through $D_1$ from the positive supply line via $R_3 - R_1$ and $R_4$, and a similar current can be passed through $D_2$ via $R_3 - R_2$ and $R_4$. The relative values of these currents can be adjusted over a limited range via $R_3$, thus enabling the forward volt drops of the diodes to be equalised, so that they give zero differential output when they are both at the same temperature.

Suppose then that the diode voltages have been equalised in this way, so that zero voltage differential exists between them. If now the temperatures of both diodes are raised by 10°C, the forward voltages of both diodes will fall by 20 mV, and zero voltage differential will still exist between them. The circuit is thus not influenced by identical changes in the temperatures of $D_1$ and $D_2$.

Suppose, on the other hand, that the temperature of $D_2$ falls 1°C below that of $D_1$. In this case the $D_2$ voltage will rise 2 mV above that of $D_1$, so the pin 3 terminal of the op-amp will go positive to the pin 2 terminal, and the op-amp will go into positive saturation and hold $Q_1$ and the relay off. Finally, suppose that the temperature of $D_2$ rises

$1°C$ above that of $D_1$. In this case the $D_2$ voltage will fall 2 mV below that of $D_1$, so the op-amp will go into negative saturation and drive $Q_1$ and the relay on. Thus the relay turns on only when the temperature of $D_2$ is above that of $D_1$ (or when the temperature of $D_1$ is below that of $D_2$). The circuit has a typical sensitivity of about 0.5°C.

In the explanation above it has been assumed that $R_3$ is adjusted so that the $D_1$ and $D_2$ voltages are exactly equalised when the two diodes are at the same temperature, so that the relay goes on when the $D_2$ temperature rises a fraction of a degree above that of $D_1$. In practice, $R_3$ can readily be adjusted so that the standing bias voltage of $D_2$ is some millivolts greater than that of $D_1$ at normal temperatures, in which case the relay will not turn on until the temperature of $D_2$ rises some way above that of $D_1$. The magnitude of this differential temperature trip level is fully variable from zero to about 10°C via $R_3$, so the circuit is quite versatile. The circuit can be set up simply by raising the temperature of $D_2$ the required amount above that of $D_1$, and then carefully adjusting $R_3$ so that the relay just turns on under this condition.

CHAPTER 4

# LIGHT-SENSITIVE ALARM CIRCUITS

Light-sensitive alarm systems have a number of important applications in the home and in industry. They can be made to activate when light enters a normally dark area, such as the inside of a storeroom or a wall safe, or they can be used to sound an alarm when an intruder or object enters a prohibited area and breaks a projected light-beam. They can be used as smoke-sensitive alarms, and alarms that activate when the light level goes above or below a preset level.

Light-sensitive alarms may be designed to give an audible loudspeaker output, an alarm-bell output, or a relay output that can be used to operate any kind of audible or visual warning device. A wide range of useful alarm types is described in this chapter. Most of the circuits use an LDR (light-dependent resistor) as a light-sensing element. The LDR is a cadmium sulphide photocell, and acts as a variable resistor that presents a high resistance (typically hundreds of kilohms) under dark conditions, and a low resistance (typically a few hundred ohms or less) when brightly illuminated. All the circuits shown in this chapter are highly versatile types, and will work well with almost any general-purpose cadmium sulphide photocells with face diameters in the range 3 mm to 12 mm; no precise LDR types are thus specified in these circuits. Notes on LDR selection are, however, given where applicable.

### Simple light-sensitive alarm circuits

*Figures 4.1* and *4.2* show a couple of very simple light-sensitive alarms, which turn on and self-latch when the illumination changes from near-dark to a moderately high level. These alarms are intended to sound

when light enters a normally dark area, such as the inside of a storeroom or a wall safe.

In the *Figure 4.1* circuit, an alarm bell is wired in series with an SCR, which is wired in the self-latching mode via $R_3$ and $S_1$. The gate drive of the SCR is derived from the $R_1-LDR-R_2$ potential divider. Under dark conditions the LDR resistance is very high, so negligible voltage appears across $R_2$, and the SCR and the alarm are both off.

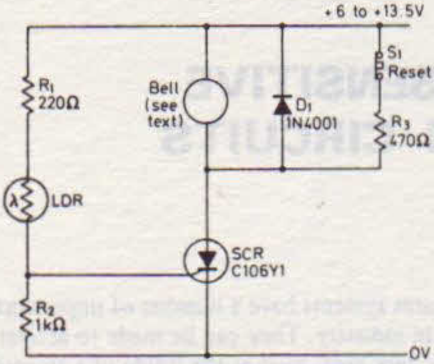



*Figure 4.1 Simple light-activated alarm, bell output*

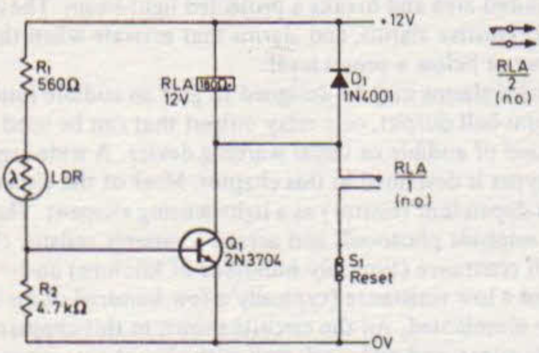



*Figure 4.2 Simple light-activated alarm, relay output*

When light enters the normally dark area and falls on the LDR face, the LDR resistance falls to a fairly low value; if this value is less than 10 kΩ or so, enough current flows through $R_2$ to turn the SCR and the alarm on, and the circuit then self-latches into the 'on' mode via $R_3$. Most LDRs give a resistance of less than 10 kΩ when exposed to low-intensity room lighting or to the light of a torch, so this circuit operates as soon as it is exposed to a moderate degree of illumination.

The *Figure 4.1* circuit can be used with any low-voltage self-interrupting alarm bell that draws a current less than 2 A. The circuit supply volts must be 1.5 V greater than the bell operating voltage. The design can be made non-latching by eliminating $R_3$ and $S_1$.

The *Figure 4.2* circuit operates in the same basic way as described above, except that an npn transistor is used in place of the SCR, and a relay is used in place of the alarm bell. The circuit can be used to activate any type of alarm device via the *RLA*/2 contacts. The relay

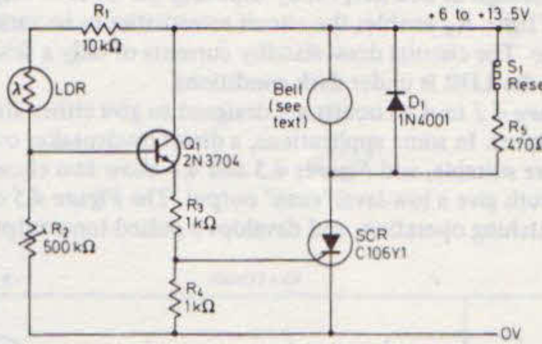



*Figure 4.3 Improved light-activated alarm, bell output*

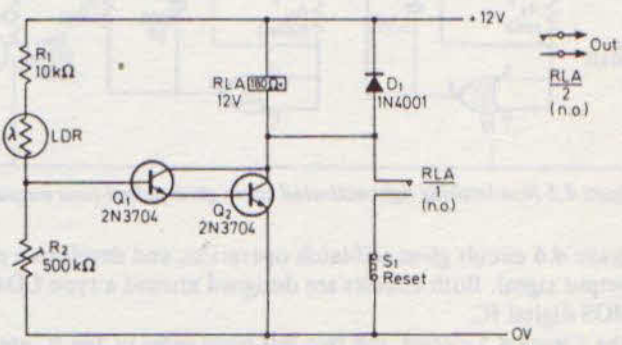



*Figure 4.4 Improved light-activated alarm, relay output*

can be any 12 V type with a coil resistance of 180 Ω or greater, and with two or more sets of n.o. contacts. The circuit can be made non-latching by eliminating $S_1$ and the *RLA*/1 contact connections.

The sensitivities of the *Figure 4.1* and *4.2* circuits can easily be increased so that the alarms turn on when only a very small amount of light falls on the LDR face. *Figures 4.3* and *4.4* show how.

The sensitivity of the *Figure 4.1* circuit is increased by replacing $R_2$ with a high-value variable resistor, and by interposing an emitter-follower buffer stage between the LDR potential divider and the gate of the SCR, as shown in *Figure 4.3*. The sensitivity of the *Figure 4.2* circuit is increased by replacing $R_2$ with a high-value variable resistor, and by replacing $Q_1$ with a super-alpha-connected pair of transistors, as shown in *Figure 4.4*.

The *Figure 4.3* and *4.4* circuits can both be turned on by LDR resistances as high as 200 kΩ, i.e. by exposing the LDR to very small amounts of light. $R_2$ enables the circuit sensitivities to be varied over a wide range. The circuits draw standby currents of only a few micro-amps when the LDR is under dark conditions.

The *Figure 4.1* to *4.4* circuits are designed to give either alarm-bell or relay outputs. In some applications, a direct loudspeaker output may be more suitable, and *Figures 4.5* and *4.6* show two circuits of this type; both give a low-level 'siren' output. The *Figure 4.5* circuit gives non-latching operation, and develops a pulsed-tone output signal.

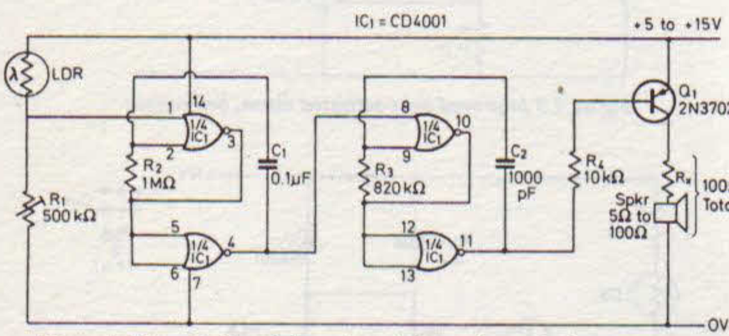



*Figure 4.5 Non-latching light-activated alarm gives pulsed-tone output*

The *Figure 4.6* circuit gives self-latch operation, and develops a mono-tone output signal. Both circuits are designed around a type CD4001 COS/MOS digital IC.

In the *Figure 4.5* circuit, the two left-hand gates of the IC are wired as a low-frequency (6 Hz) gated astable multivibrator that is activated by the light level, and the two right-hand gates are wired as an 800 Hz astable multivibrator that is activated via the 6 Hz astable. Under dark conditions both multivibrators are inoperative, and the circuit consumes a low standby current. Under bright conditions, on the other hand, both astables are activated, and the low frequency circuit pulses the 800 Hz astable on and off at a rate of 6 Hz, so a pulsed 800 Hz tone is generated in the speaker.

In the self-latching circuit of *Figure 4.6*, the two left-hand gates of the IC are wired as a simple bistable multivibrator, and the two right-hand gates are wired as a gated 800 Hz astable multivibrator that is activated via the bistable. Under dark conditions the output of the

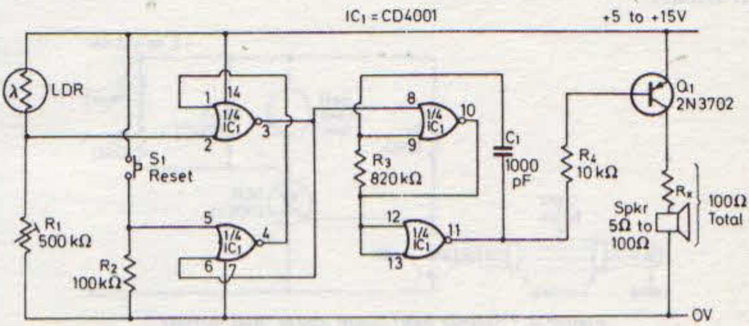



*Figure 4.6 Self-latching light-activated alarm gives monotone output*

bistable is normally high, and the astable is disabled, so the circuit consumes only a small standby current. When the LDR is exposed to bright light the bistable changes state and its output locks into the low state and activates the astable multivibrator. An 800 Hz tone signal is generated in the speaker under this condition. Once it has been activated, the circuit can only be turned off again by removing the illumination from the LDR and briefly closing 'reset' switch $S_1$, at which point the output of the bistable resets to the high state.

Note that the *Figure 4.5* and *4.6* circuits give output powers of only a few milliwatts, but that these levels can be boosted to as high as 18 W by replacing their $Q_1$ output stages with the power-boosting circuits of *Figures 1.9* or *1.10*.

## Light-beam alarm circuits

Alarm circuits of this type are intended to activate when a person or object enters or 'breaks' a projected light-beam. *Figures 4.7* and *4.8* show two very simple light-beam alarm circuits.

In the *Figure 4.7* circuit, the SCR is wired in the self-latching mode, uses a self-interrupting bell as its anode load, and has its gate current taken from the potential divider formed by $R_1$ and the LDR. Normally, the LDR is brightly illuminated via a light-beam formed by a remotely placed lamp and lens system, so the LDR acts as a low resistance under

this condition, and insufficient voltage is developed at the $R_1 - LDR$ junction to turn the SCR on. When a person or object enters the light beam, the beam is broken and the resistance of the LDR rises to a fairly high value. Under this condition enough voltage is developed at the $R_1 - LDR$ junction to turn the SCR on, so the alarm goes on and self-latches.

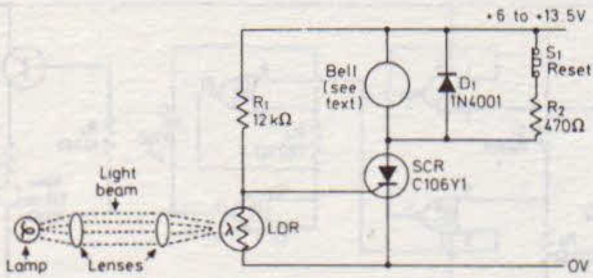



*Figure 4.7 Simple light-beam alarm, bell output*

The *Figure 4.8* circuit operates in the same basic way as described above, except that an npn transistor is used in place of the SCR, and a relay is used in place of the alarm bell. The circuit can be used to activate any type of alarm device via the *RLA*/2 contacts. The relay can be any 12 V type with a coil resistance of 180 Ω or greater, and with two or more sets of n.o. contacts. The circuit can be made non-latching by eliminating $S_1$ and the *RLA*/1 contact connections.

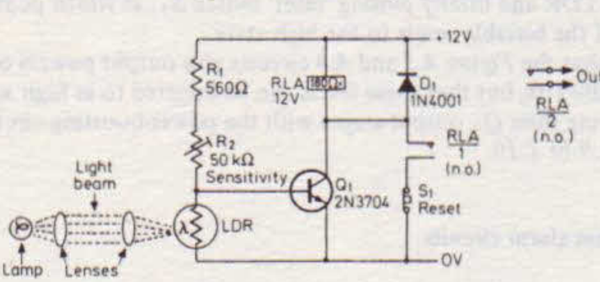



*Figure 4.8 Simple light-beam alarm, relay output*

The LDRs used in the *Figure 4.7* and *4.8* circuits can be any types that offer resistances of less than 1 kΩ under the illuminated condition, and more than 3 kΩ under the interrupted condition. The sensitivities of these circuits can readily be increased, so that the circuits can be used with any type of LDR, by using the connections shown in *Figures 4.9* and *4.10* respectively.

The *Figure 4.7* circuit is modified by interposing an emitter-follower stage between the $R_1 - LDR$ junction and the gate of the SCR, and by using a high-value variable resistor in the $R_1$ position, as shown in *Figure 4.9*. The *Figure 4.8* circuit is modified by using a super-alpha pair of transistors in place of $Q_1$, and by increasing the values of the potential divider components, as shown in *Figure 4.10*.

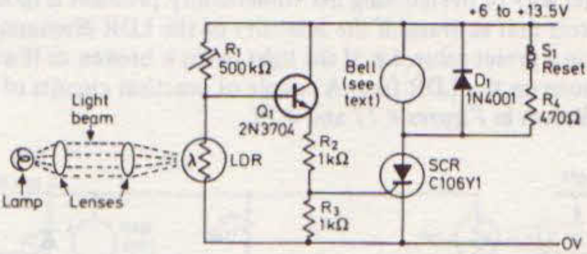



*Figure 4.9 Improved light-beam alarm, bell output*

The circuits of *Figures 4.7* to *4.10* can perform as useful intrusion detectors. They are inexpensive and easy to build. The lamps that activate them can be powered from either a.c. or d.c. supplies. A disadvantage of each circuit, however, is that it can be disabled by directing a bright light on to the LDR face. If this light has an intensity greater than that of the normal light beam, an intruder can walk through the beam without activating the alarm. This vulnerability of the basic light-beam alarm can be overcome in a number of ways.

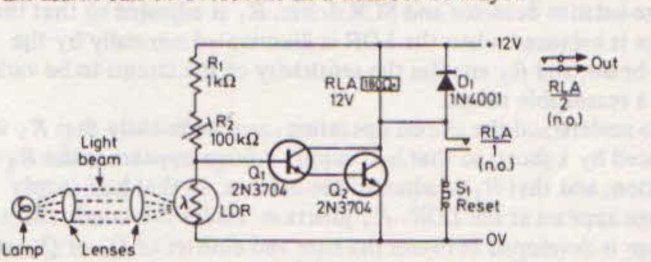



*Figure 4.10 Improved light-beam alarm, relay output*

One system that overcomes this particular vulnerability problem uses a code-modulated light-beam, and employs code-sensitive detector circuitry in its alarm section. The circuit cannot be disabled by shining a light on the LDR, since the alarm is sensitive only to the correct code signals. Modulated-light-beam systems of this type are widely used, and

are sometimes quite complex and expensive. The value of these systems has been considerably reduced in recent years by the development of glass-fibre light tubes or 'light pipes', however. Skilled intruders can use these pipes to divert the coded beam away from its original protected path without breaking its effective source-to-detector link, and can then pass through the original protected area without activating the alarm system.

Another way of overcoming the vulnerability problem is to use an alarm circuit that activates if the intensity of the LDR illumination varies from a preset value, i.e. if the light-beam is broken or if a bright light is shone on the LDR face. A couple of practical circuits of this type are shown in *Figures 4.11* and *4.12*.

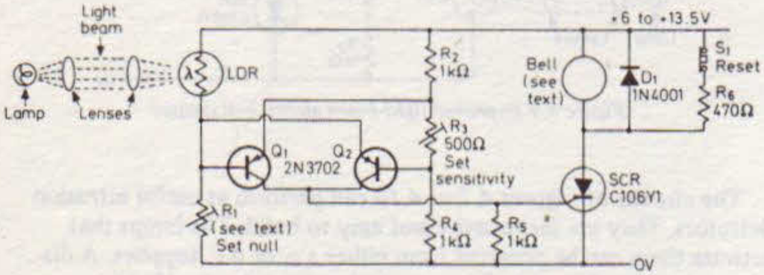



*Figure 4.11 'Unbeatable' light-beam alarm, bell output*

In the *Figure 4.11* circuit, the LDR is wired in a bridge circuit formed by $R_1-R_2-R_3-R_4$ and the LDR, and $Q_1-Q_2$ are used as a bridge-balance detector and SCR driver. $R_1$ is adjusted so that the bridge is balanced when the LDR is illuminated normally by the light-beam, and $R_3$ enables the sensitivity of the circuit to be varied over a reasonable range.

To understand the circuit operation, assume initially that $R_3$ is replaced by a short, so that half-supply voltage appears at the $R_2-R_4$ junction, and that $R_1$ is adjusted for balance, so that half-supply voltage appears at the *LDR*$-R_1$ junction. Under this condition, zero voltage is developed between the base and emitter of $Q_1$ or $Q_2$, so both transistors are cut off and zero current flows into the gate of the SCR. The alarm is thus off under this condition.

Suppose now that the light-beam is interrupted, so that the LDR resistance rises. Under this condition the voltage at the *LDR*$-R_1$ junction falls to a value lower than that on the $R_2-R_4$ junction, so a forward voltage appears between the base and emitter of $Q_1$. If this voltage exceeds 650 mV or so, $Q_1$ is driven on and its collector current

feeds into the SCR gate, and the alarm circuit then turns on and self-latches.

Alternatively, suppose that the beam is not interrupted, but that a light with an intensity greater than that of the beam is shone on the LDR face. In this case the LDR resistance falls, so the voltage at the $LDR - R_1$ junction rises above that of the $R_2 - R_4$ junction. A forward voltage, thus appears between the base and emitter of $Q_2$; if this voltage exceeds 650 mV or so, the transistor is driven on and its collector current feeds into the SCR gate, driving the alarm on. The alarm thus activates if the light intensity on the LDR face changes sufficiently to forward bias either transistor.

In the practical circuit of *Figure 4.11*, $R_3$ is wired in series with the $R_2 - R_4$ potential divider, and enables a preset forward-bias voltage to be applied to the base–emitter junctions of $Q_1$ and $Q_2$, so that the circuit's sensitivity can be controlled. If, for example, a preset bias of 500 mV is applied to each transistor, the LDR only has to produce an additional change of 150 mV to turn one or other of the transistors on and thus activate the alarm. The circuit can thus be adjusted to a high degree of sensitivity, so that its immunity to 'disabling' by intruders can be as good as, or better than, that of even the most expensive modulated-light-beam systems.

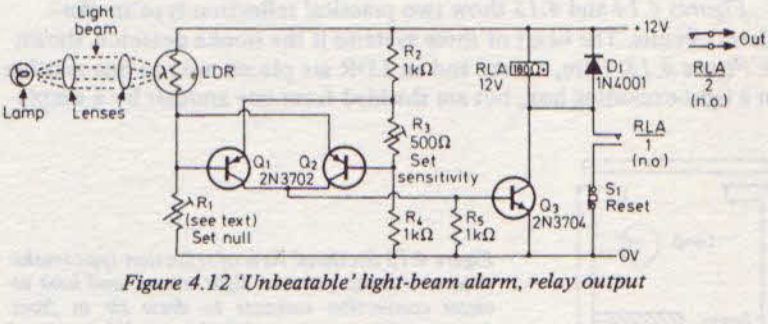



*Figure 4.12 'Unbeatable' light-beam alarm, relay output*

The *Figure 4.12* circuit is similar to that described above, except that the SCR and alarm bell are replaced by an npn transistor and a self-latching relay. This circuit can be used to activate any type of electrical alarm device via the relay contacts.

The LDR used in these circuits can be any type with a resistance in the range 200 Ω to 2 kΩ when illuminated by the light beam. $R_1$ should have a maximum value roughly double that of the LDR under the above condition, so that the two resistances are roughly equal when $R_1$ is set at mid-value. The sensitivity of each circuit varies

slightly with changes in supply voltage, and is greatest at higher voltage levels. If the circuits are to be used at very high sensitivities, therefore, the supply voltages should be stabilised. To set up the circuits for use, proceed as follows.

First, adjust $R_1$ so that half-supply voltage is developed at the $LDR-R_1$ junction when the LDR is illuminated via the light beam, and then adjust $R_3$ so that roughly 400 mV are developed across $R_5$. Now readjust $R_1$ to give a minimum reading across $R_5$; readjust $R_3$, if necessary, so that this reading does not fall below 200 mV. When the $R_1$ adjustment is complete, the bridge is correctly balanced. $R_3$ can then be adjusted to set the sensitivity to the required level. If $R_3$ is set so that zero voltage is developed across $R_5$, fairly large changes in light level will be needed to operate the alarm; if it is set so that a few hundred millivolts are developed across $R_5$, only small changes will be needed to operate the alarm.

**Smoke-alarm circuits**

Another useful type of light-sensitive alarm is the so-called 'smoke' alarm. This may be of either the 'reflection' type or the 'light-beam' type.

*Figures 4.14* and *4.15* show two practical reflection-type smoke-alarm circuits. The heart of these systems is the smoke detector, shown in *Figure 4.13*. Here, a lamp and an LDR are placed next to one another in a light-excluding box, but are shielded from one another by a simple

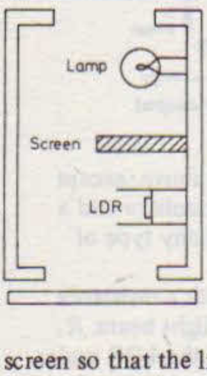



*Figure 4.13 Sectional view of reflection-type smoke detector. Lamp provides light source, and heat to cause convection currents to draw air in from bottom of box and expel it through lid; inside of box is painted matt black; construction lets air pass through box but excludes external light*

screen so that the light of the lamp does not fall directly on to the face of the LDR. The inside of the box is painted matt black, so that the LDR is not illuminated by light reflected from the inside of the box.

The construction of the box is such that its top and bottom are open to the air, but exclude external light. The lamp is placed near the top of the box, and inevitably generates a certain amount of heat. This heat rises out of the top of the box and sucks cooler air in through the bottom. Thus a continuous current of air is passed through the box

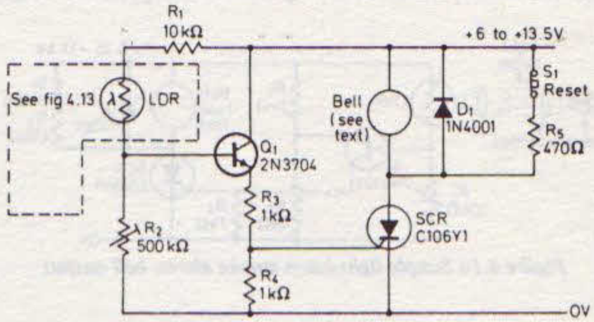



*Figure 4.14 Reflection-type smoke alarm, bell output*

and past the face of the LDR. If this air is smoke-free it is invisible and does not reflect the light of the lamp, so the LDR remains in darkness and presents a high resistance. Alternatively, if the circulating air is laden with smoke it reflects the light of the lamp on to the face of the LDR, and the LDR resistance falls to a fairly low value. This reduction of the LDR resistance can be used to operate a simple alarm circuit.

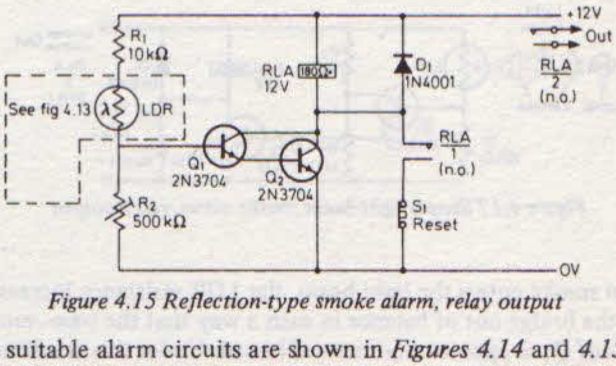



*Figure 4.15 Reflection-type smoke alarm, relay output*

Two suitable alarm circuits are shown in *Figures 4.14* and *4.15*; they are virtually identical to those shown in *Figures 4.3* and *4.4* respectively, and activate when the LDR resistance falls below a preset amount. When used in conjunction with the smoke detector of *Figure 4.13*, these circuits thus act as 'smoke' alarms. The circuits are simple and give reliable operation.

In the alternative 'light-beam' type of smoke alarm, a light-beam is projected across the protected area and on to the face of an LDR, which forms part of a sensitive detector circuit. When smoke enters the light-beam, the intensity of the illumination on the LDR face falls slightly, and the LDR resistance rises. This increase of resistance is used to activate the alarm, which thus responds to the presence of smoke.

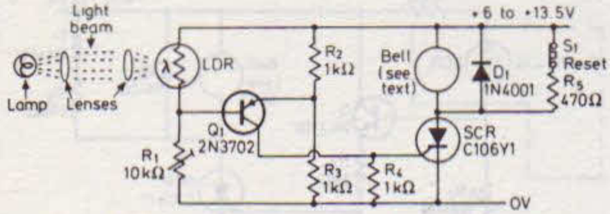



*Figure 4.16 Simple light-beam smoke alarm, bell output*

Two simple light-beam smoke-alarm circuits are shown in *Figures 4.16* and *4.17*. In the *Figure 4.16* circuit, the LDR and $R_1-R_2-R_3$ are wired in the form of a simple bridge. $R_1$ is adjusted so that the bridge is out of balance in such a way that $Q_1$ is not quite biased on when the LDR is normally illuminated by the light beam. Under this condition $Q_1$ passes negligible collector current into the gate of the SCR, so the alarm is off.

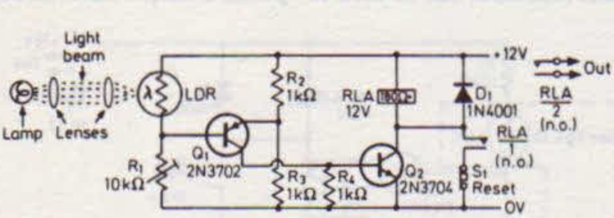



*Figure 4.17 Simple light-beam smoke alarm, relay output*

When smoke enters the light beam, the LDR resistance increases and throws the bridge out of balance in such a way that the base–emitter junction of $Q_1$ is appreciably forward biased. Under this condition, $Q_1$ passes substantial collector current into the gate of the SCR, and the alarm turns on and self-latches.

The *Figure 4.17* circuit is similar to that described above, except that an npn transistor and a self-latching relay are used in place of the SCR and alarm bell.

A snag with the *Figure 4.16* and *4.17* circuits is that their trigger points are slightly affected by variations in temperature, since the $V_{be}$ characteristics of $Q_1$ are temperature dependent. The circuits are thus not suitable for use in conditions of large temperature variation or at high sensitivity levels.

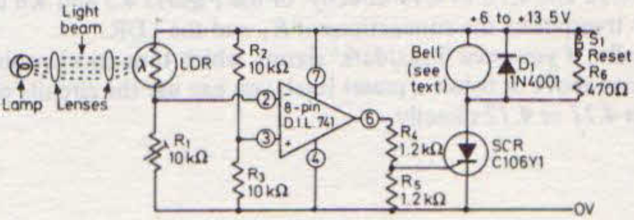



*Figure 4.18 Sensitive light-beam smoke alarm, bell output*

These snags are largely overcome in the two sensitive smoke-operated alarm circuits of *Figures 4.18* and *4.19*. Here, the LDR is again connected in the bridge network formed by the LDR and $R_1$–$R_2$–$R_3$, but in this case the operational amplifier is used as the bridge-balance detector. An outstanding feature of the op-amp is that its operating points are not greatly affected by variations in ambient temperature or supply voltage. Consequently these circuits give very stable operation.

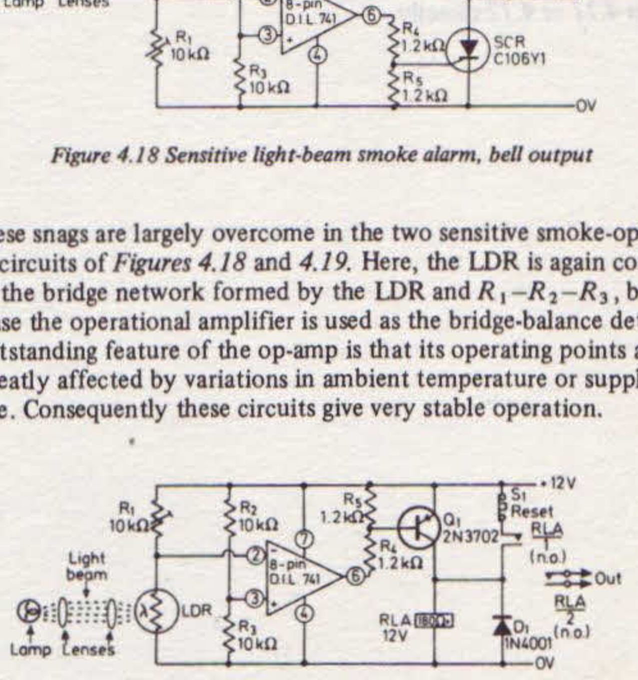



*Figure 4.19 Sensitive light-beam smoke alarm, relay output*

In the *Figure 4.18* circuit the op-amp is used to operate the alarm bell via the SCR, while in the *Figure 4.19* circuit it is used to operate the self-latching relay via $Q_1$. Note that if these circuits are to be used at their maximum sensitivity levels it may be necessary to feed the light-beam energising lamps from regulated power sources, so that the illumination levels of the light beams are stabilised to a reasonable degree.

**'Dark' and 'light/dark' alarm circuits**

Most of the circuits shown in this chapter can be used, or adapted for use, in applications other than those for which they were specifically designed. If you need 'dark-operated' circuits, which turn on when the light level falls below a preset value, you can use the circuits of *Figures 4.7* to *4.10* and *4.16* to *4.19* directly, or use *Figures 4.5* and *4.6* by simply transposing the connections of $R_1$ and the LDR.

Finally, if you need 'light/dark' alarms, which turn on when the light goes above or below a preset level, you can use the circuits of *Figures 4.11* or *4.12* directly.

CHAPTER 5

# MISCELLANEOUS ALARM CIRCUITS

In each of the four preceding chapters we have looked at a specific class of alarm system. In this chapter we look at a miscellaneous range of alarm circuits that can also be used in the home or in industry.

The circuits presented here include liquid and steam-activated alarms, power-failure alarms, an ultrasonic beam alarm, and sound or vibration alarms.

## Liquid and steam-activated alarms

Liquid- and steam-activated alarms have a number of uses. Liquid-activated alarms can be made to sound when the water in a bath or the liquid in a tank reaches a preset level, or when rain falls across a pair of contacts, or when flooding occurs in a cellar or basement, or when an impact wave is generated as a person or object falls into a swimming pool or tank.

Steam-activated alarms can be made to sound when high-pressure steam escapes from a valve or a fractured pipe, or when steam emerges from the spout of a kettle or container as the liquid reaches its boiling point.

Five liquid- or steam-activated alarm circuits are described. All the circuits use the same basic principle of operation. In each case, a pair of metal probes detects the presence or absence of the liquid or steam. In the absence of the medium the probes 'see' a near-infinite resistance, but in the presence of the medium the probe resistance falls to a

relatively low value. This fall in resistance is detected and made to activate the alarm device. The resistance appearing across the probes under the alarm condition depends on the type of medium that is being detected. In the case of rain or tap water, the resistance may be less than a few kilohms, but in the case of steam or oil the resistance may be greater than several megohms.

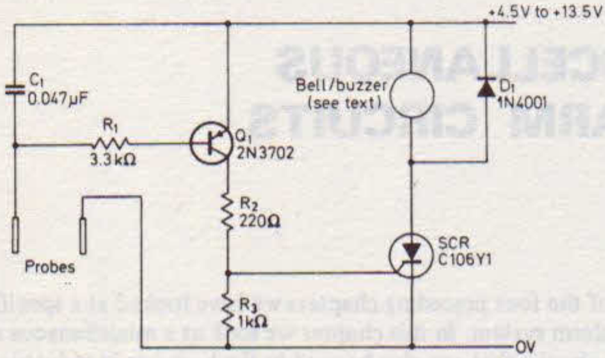



*Figure 5.1 Simple liquid- or steam-activated alarm, bell/buzzer output*

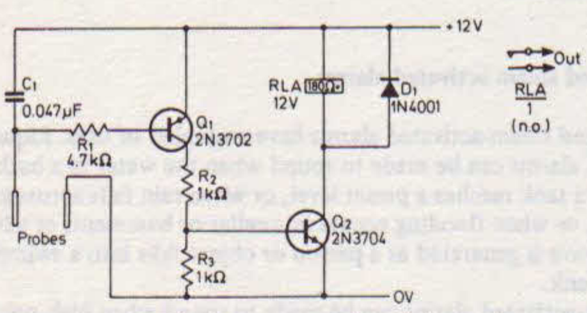



*Figure 5.2 Simple liquid- or steam-activated alarm, relay output*

Two simple liquid-activated alarm circuits, which can be activated by probe resistances up to about 500 kΩ, are shown in *Figures 5.1* and *5.2.* Both circuits operate in the same basic way, and give a non-latching form of operation. The former gives an alarm bell or buzzer output, and the latter gives a relay output that can be used to activate any type of alarm device via the relay contacts.

In the case of the *Figure 5.1* circuit, $Q_1$ is cut off when the probes are open-circuit, so the SCR and alarm are also off. When a resistance less than 500 kΩ or so is connected across the probes, $Q_1$ is biased on to such a level that its collector current turns on the SCR, and the alarm-bell or buzzer activates. Note that this bell or buzzer must be a self-interrupting device, so that the alarm turns off when the resistance is removed from the probes. The circuit supply voltage must be 1.5 V greater than the bell or buzzer operating voltage, and the alarm device must pass a current of less than 2 A.

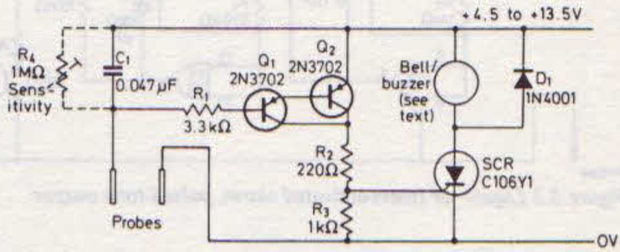



*Figure 5.3 Sensitive liquid- or steam-activated alarm, bell/buzzer output*

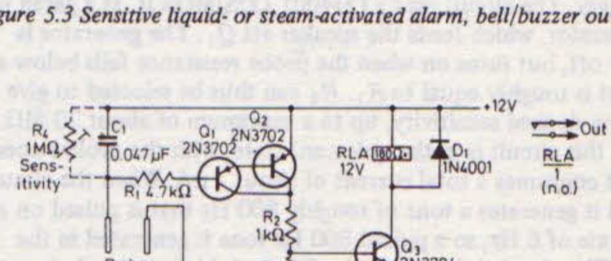



*Figure 5.4 Sensitive liquid- or steam-activated alarm, relay output*

The *Figure 5.2* circuit is similar to that described above, except that the SCR is replaced by an npn transistor, and a 12 V relay is used in place of the bell or buzzer. The relay must have a coil resistance more than 180 Ω. Its contacts can be used to activate any type of external alarm device.

The circuits of *Figures 5.1* and *5.2* can easily be modified so that they are activated by probe resistances up to about 20 MΩ. *Figures 5.3* and *5.4* show how. In each case, $Q_1$ is simply replaced by a super-alpha-connected pair of pnp transistors. These circuits also show how the

sensitivity of the designs can be made variable by wiring a 1 MΩ preset resistor (shown dotted) across $C_1$. $C_1$ is used to protect the circuits against activation by spurious or radiated signals.

Finally, *Figure 5.5* shows the circuit of a liquid- or steam-activated alarm that gives a pulsed-tone low-level output signal directly into a

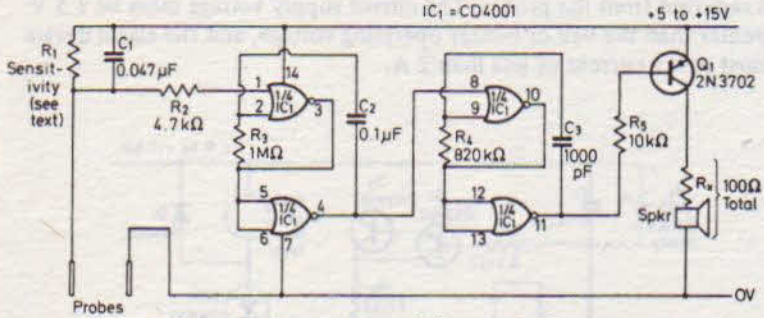



*Figure 5.5 Liquid- or steam-activated alarm, pulsed-tone output*

loudspeaker. The circuit uses a CD4001 COS/MOS IC as a gated pulse-tone generator, which feeds the speaker via $Q_1$. The generator is normally off, but turns on when the probe resistance falls below a value that is roughly equal to $R_1$. $R_1$ can thus be selected to give the circuit any desired sensitivity, up to a maximum of about 20 MΩ.

When this circuit is in the quiescent state, with the probes open-circuit, it consumes a total current of about 1 µA. When the circuit is activated it generates a tone of roughly 800 Hz that is pulsed on and off at a rate of 6 Hz, so a pulsed 800 Hz tone is generated in the speaker. The circuit is based on the *Figure 1.11* design and gives an output power of only a few milliwatts. The power can be boosted as high as 18 W by replacing the $Q_1$ output stage by one or other of the *Figure 1.9* and *1.10* power-boosting stages.

**Power-failure alarm circuits**

Electrical power-failure alarms can be made to activate when power is removed from a deep-freeze unit, or when a burglar cuts through power lines, or when a machine overloads and blows its fuses. Three useful power-failure alarm circuits are described in this section.

*Figure 5.6* shows a simple relay-output power-failure alarm, which can be used to activate any type of external alarm device via the relay

contacts. Here, the power-line input is applied to a step-down transformer, which gives an output of 12 V. This output is half-wave rectified by $D_1$ and smoothed by $C_1$, and the resulting d.c. is fed directly to the relay coil. The n.c. contacts of the relay are used to apply power to the external alarm device.

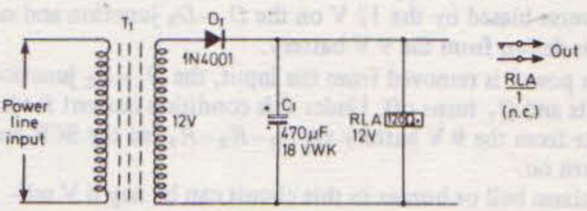



*Figure 5.6 Simple power-failure alarm, relay output*

Thus when power is applied to the circuit the relay is driven on, its contacts are open and the alarm is off, but when the power input is removed the relay turns off, so its contacts close and activate the alarm device.

The relay can be any 12 V type with a coil resistance of 120 Ω or greater, and with one or more sets of n.c. contacts. $T_1$ can be any power-line step-down transformer that gives a 12 V output at a current above 100 mA.

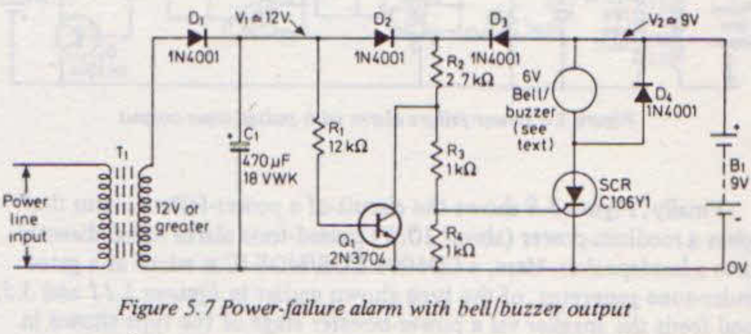



*Figure 5.7 Power-failure alarm with bell/buzzer output*

An alternative type of power-failure alarm is shown in *Figure 5.7*. Here, the power input is stepped down to 12 V by $T_1$ and is rectified and smoothed by $D_1$ and $C_1$, to give roughly 12 V d.c. at the $D_1-D_2$

and $D_2-D_3$ junctions. The actual alarm device, which is a self-interrupting bell or buzzer, is used as the anode load of the SCR and is powered from a 9 V battery.

Normally, when power is applied, 12 V d.c. are developed at the $D_1-D_2$ and $D_2-D_3$ junctions, so $Q_1$ is driven to saturation via $R_1$, and the $R_2-R_3$ junction is pulled down to zero volts. Under this condition zero drive is applied to the SCR gate, so the alarm is off and $D_3$ is reverse-biased by the 12 V on the $D_2-D_3$ junction and no current is drawn from the 9 V battery.

When power is removed from the input, the $D_1-D_2$ junction falls to zero volts and $Q_1$ turns off. Under this condition current feeds to the SCR gate from the 9 V battery via $D_3-R_2-R_3$, so the SCR and the alarm turn on.

The alarm bell or buzzer in this circuit can be any 6 V self-interrupting type that draws less than 2 A. The step-down transformer can be any type that gives a 12 V output at a current of a few milliamps.

If this circuit is modified for use with alternative voltages, it is essential that the voltage at the $D_1-D_2$ junction be at least 2 V greater than the battery volts.

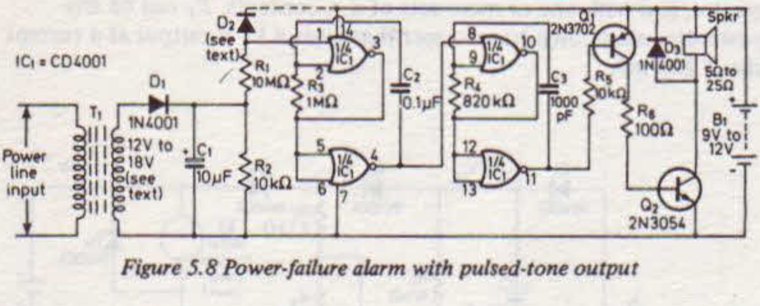



*Figure 5.8 Power-failure alarm with pulsed-tone output*

Finally, *Figure 5.8* shows the circuit of a power-failure alarm that gives a medium-power (about 10 W) pulsed-tone alarm signal directly into a loudspeaker. Here, a CD4001 COS/MOS IC is wired as a gated pulse-tone generator, of the type shown earlier in *Figures 1.11* and *5.5*, and feeds the speaker via a power-booster stage of the type shown in *Figure 1.9*.

In this circuit the power-line signal is again stepped down, rectified and smoothed by $T_1-D_1-C_1$. When power is applied the voltage across $C_1$ is greater than that of the supply battery, so the input gate

of the IC is clamped to the battery positive-rail voltage via $R_1$ and the gate-input protection diode (shown dotted as $D_2$) of the IC, and the generator is gated off. Under this condition the circuit consumes only a small leakage current from the battery.

When power is removed from the input of the circuit the $C_1$ voltage falls to zero. Under this condition the IC is gated on, and an alarm signal is generated in the speaker. This signal has a basic frequency of 800 Hz, and is pulsed on and off at 6 Hz. The step-down transformer used can be any type that causes a voltage greater than that of the battery to be developed across $C_1$.

## Proximity alarm circuits

As the name indicates, proximity alarms can be made to activate when a person or object touches or comes close to a sensing antenna or a conducting object attached to the antenna. Two practical proximity alarm circuits are described, both using the same basic principle of operation. One circuit (*Figure 5.9*) gives a relay output, the other (*Figure 5.10*) gives a direct alarm-bell or buzzer output.

Both circuits work on the capacitive loading principle, in which the gain of an r.f. oscillator is adjusted to a critical point at which oscillation is barely sustained, and in which the antenna forms part of the tank circuit. In these circuits one of the supply lines is grounded.

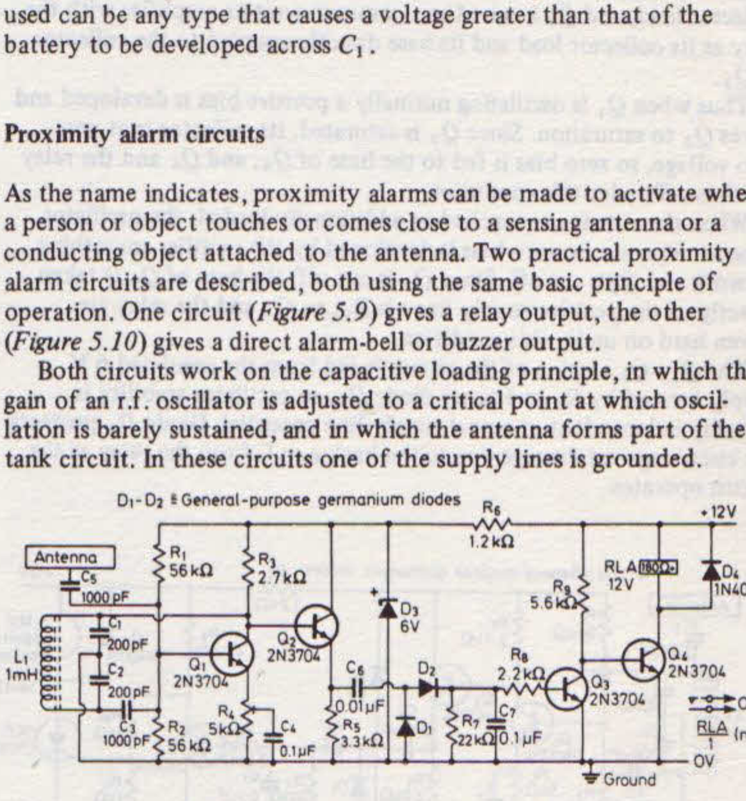



*Figure 5.9 Relay-output proximity alarm*

Consequently any increase in the antenna-to-ground capacitance, such as is caused by touching or nearing the antenna, causes enough damping of the tank circuit to bring the oscillator gain below the critical level, and the oscillator ceases to operate. This cessation of oscillation is then used to make the alarm generator activate.

*Figure 5.9* shows the practical circuit of a relay-output system that uses the above principle. Here, transistor $Q_1$ is wired as a Colpitts oscillator, with gain adjustable via $R_4$, and the antenna is coupled to the base of $Q_1$ via $C_5$. The output of this oscillator, which operates at about 300 kHz, is made available at a low impedance level across $R_5$ via emitter-follower $Q_2$. This signal is rectified and smoothed via $D_1-D_2-R_7$ and $C_7$, to produce a positive bias that is fed to the base of $Q_3$ via $R_8$. $Q_3$ is wired as a common-emitter amplifier, with $R_9$ as a collector load, and $Q_4$ is wired as a common-emitter amplifier with the relay as its collector load and its base directly coupled to the collector of $Q_3$.

Thus when $Q_1$ is oscillating normally a positive bias is developed and drives $Q_3$ to saturation. Since $Q_3$ is saturated, its collector is at near-zero voltage, so zero bias is fed to the base of $Q_4$, and $Q_4$ and the relay are thus off under this condition.

When the antenna is touched or additionally loaded, the oscillator ceases to operate, so zero bias is developed by the rectifier-smoothing network and $Q_3$ is cut off. Since $Q_3$ is cut off, the base of $Q_4$ is taken directly to the positive supply line via $R_9$, so $Q_4$ and the relay are driven hard on under this condition.

The $Q_1-Q_2$ section of the circuit is fed from the regulated 6 V supply formed by $R_6$ and zener diode $D_3$, so oscillator stability is virtually independent of actual supply-line potential. Diode $D_4$ protects the circuit against damage due to the back e.m.f. from the relay as the circuit operates.

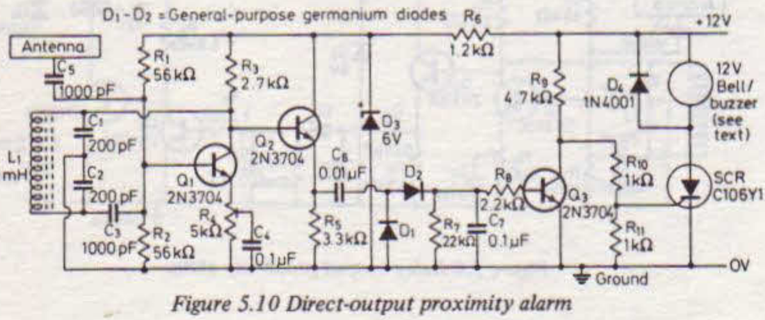



*Figure 5.10 Direct-output proximity alarm*

The direct-output version of the circuit, shown in *Figure 5.10*, is similar to that described above, except that an SCR is used in place of $Q_4$, and an alarm device is used directly as the anode load of the SCR.

This alarm device can be any self-interrupting bell or buzzer with a rating in the range 9–12 V at up to 2 A.

Note that the *Figure 5.9* and *5.10* circuits are both designed to give non-latch operation. The *Figure 5.9* circuit can be made self-latching by wiring a spare set of n.o. relay contacts between the collector and emitter of $Q_4$, and the *Figure 5.10* circuit can be made self-latching by wiring a 470 Ω resistor in parallel with $D_4$.

The two circuits are very simple to set up. First connect a suitable antenna, then turn $R_4$ towards the ground rail until the alarm just activates. Next, turn $R_4$ back a fraction so that the relay just turns off, then check that the alarm goes on when the antenna is touched or closely approached, and goes off again when the touch is removed. If necessary, adjust $R_4$ again for maximum sensitivity.

The final sensitivity of each circuit depends on the setting of $R_4$ and on the size of antenna used. If the antenna is very small, such as a short length of wire, the circuits will act as little more than touch alarms, but if the antenna is large, such as a sheet of metal, the circuits may be made sensitive enough to activate when a person approaches within a foot or two of the antenna. It pays to experiment with different types of antenna, to get the 'feel' of the circuits. Remember, however, that it is imperative that the antenna be well isolated from ground, and that one side of the circuit's power supply be taken to an effective ground connection. In some applications a floating artificial ground (such as a metal plate) can be used with advantage. If, for example, two metal plates are placed parallel a foot or so apart, and one is used as the antenna and the other as an artificial ground, the alarm will activate whenever a hand is placed between the two plates. Such a system can be used to sound an alarm if a hand is placed inside a small cabinet, etc.

## Touch alarm circuits

Touch alarms are intended to activate when a person or object touches a fixed contact point. They work in a number of ways. They may be activated by touching and closing a simple microswitch, as in the contact alarm circuits described in Chapter 1, or they may work on the capacitive loading principle described in the preceding section of this chapter. Alternatively, they may be activated by the a.c. hum that is picked up by an electrical contact when it is touched by a human finger (in equipment that is connected to a.c. power lines), or by the relatively low resistance (less than a few megohms) that appears across a pair of contacts when they are bridged by a human finger. Three circuits of the latter two types are described in this section.

*Figure 5.11* shows a simple but useful 'hum-detecting' touch alarm circuit. Here, one of the gates of a CD4001 COS/MOS IC is wired as a simple pulse-inverting amplifier, and has its high-impedance input terminal taken to a pick-up contact via $R_2$. The gate is effectively powered from a 5 V supply, derived from the 12 V line via $R_3$ and $R_4$, and is biased via $R_1$ so that its output is normally low.

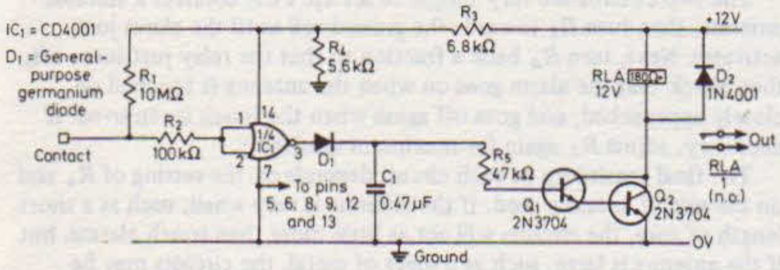



*Figure 5.11 'Hum-detecting' touch alarm*

When a pick-up signal with a peak amplitude greater than a couple of volts is applied to the pick-up contact, the output of the gate pulses on and off at line frequency, and a square wave with a peak amplitude of about 5 V is developed at the gate output terminal. This square wave is rectified and smoothed via $D_1$ and $C_1$, and the resulting d.c. is used to drive RLA on via $Q_1 - Q_2$ and $R_5$.

Note when using this circuit that the low side of the 12 V supply must be grounded, and that any type of external alarm device can be activated via the circuit's relay contacts. The circuit draws a standby current of 1 mA. Since the circuit must be operated from a.c. power lines, this current drain should present no problems.

The pick-up contact of the above circuit should be limited in size to a few square centimetres. If the contact is to be placed more than about 10 cm away from the input terminal of the COS/MOS gate, the connecting leads must be screened to prevent the pick-up of unwanted signals.

A simple resistance-sensing touch alarm circuit is shown in *Figure 5.12.* Here, one of the gates of a CD4001 IC is again wired as a pulse inverter, but is powered directly from the 12 V supply line. The input of the inverter is strapped to the positive supply line via 10 MΩ resistor $R_1$, so its output is normally low. The output is used to drive $Q_1$ and the relay via $R_3$.

The circuit action is such that the output of the inverter is low and $Q_1$ and the relay are off when a resistance much greater than 10 MΩ appears across the touch contacts, but the output of the inverter goes high and $Q_1$ and the relay turn on when a resistance less than 10 MΩ appears across the touch contacts. If the touch contacts have a surface

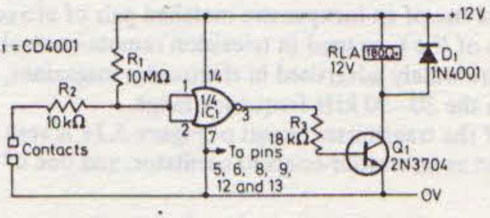



*Figure 5.12 Resistive touch alarm, normal contacts*

area of at least half a square centimetre each, a resistance of less than 10 MΩ will appear between them when they are simultaneously touched by an area of human skin, so the circuit acts effectively as a touch alarm. Any type of alarm device can be activated via the relay contacts, and the circuit consumes a typical standby current of only 1 μA.

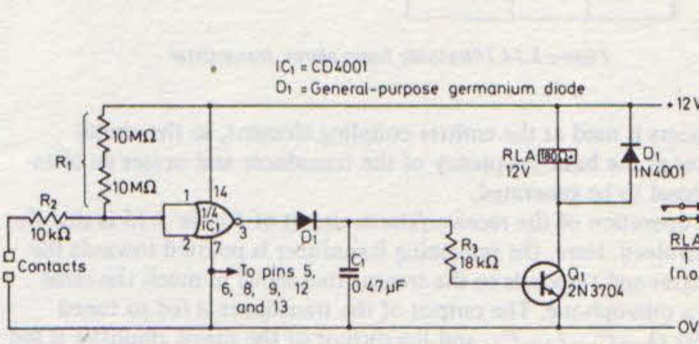



*Figure 5.13 Resistive touch alarm, micro-contacts*

Finally, *Figure 5.13* shows how the above circuit can be modified for use with micro-sized touch contacts. The circuit is similar to that described above, except that $R_1$ is increased to 20 MΩ by wiring two 10MΩ resistors in series, and that the design is also made sensitive to hum pick-up signals via $D_1$ and $C_1$. The sensitivity of this circuit is such that it can be used with pinhead-sized touch contacts.

**An ultrasonic beam alarm**

This unit can be used in the same type of application as the light-beam alarm circuits described in Chapter 4, but uses an invisible ultrasonic beam in place of a visible light beam. The circuit of the beam transmitter is shown in *Figure 5.14,* and the receiver/alarm is shown in *Figure 5.15.*

The circuits make use of an inexpensive matched pair of ultrasonic ceramic transducers of the type used in television remote-control units. These transducers are widely advertised in electronics magazines, and normally operate in the 30–50 kHz frequency range.

The operation of the transmitter circuit of *Figure 5.14* is very simple. $Q_1$ and $Q_2$ are wired as an emitter-coupled oscillator, and one of the

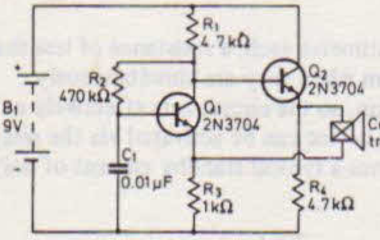



*Figure 5.14 Ultrasonic beam alarm, transmitter*

transducers is used as the emitter coupling element, so the circuit oscillates at the basic frequency of the transducer and causes an ultrasonic signal to be generated.

The operation of the receiver/alarm circuit of *Figure 5.15* is slightly more involved. Here, the remaining transducer is pointed towards the transmitter and responds to the transmitted signal in much the same way as a microphone. The output of the transducer is fed to tuned amplifier $Q_1-C_1-L_1-C_2$, and the output of the tuned amplifier is fed to an amplifying detector stage that is built around $Q_2-D_1$ and $C_3$. Normally, when the ultrasonic beam is unbroken, the output of this detector stage is high, so $Q_3$ is driven to saturation and $Q_4$ and the relay are cut off. When the beam is interrupted, the output of the detector stage falls to near zero volts, so $Q_3$ turns off and $Q_4$ and the relay are turned on via $R_8$. Any type of alarm device can be activated by the closing of the relay contacts. Thus the alarm is normally off, but turns on when the ultrasonic beam is interrupted.

The *Figure 5.15* circuit consumes a typical quiescent current of 5 mA, and the system has an operating range up to several yards. To set up the circuit, simply point the two transducers at one another over the required range, then carefully adjust $R_4$ so that 2 V d.c. are registered

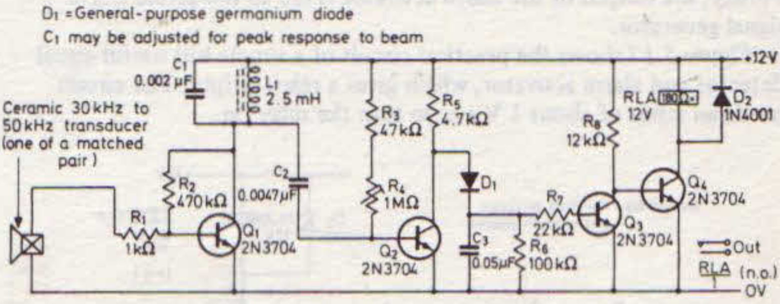



*Figure 5.15 Ultrasonic beam alarm, receiver*

across $C_3$ (on the 10 V range of a meter having a sensitivity of at least 20 kΩ/V) when the beam is uninterrupted. Then break the beam, and check that the voltage falls to near zero and the alarm turns on. If required, the value of $C_1$ can be adjusted to obtain optimum response at the ultrasonic operating frequency.

## Sound and vibration alarm circuits

Sound-activated alarms can usefully be made to activate when an intruder enters a protected area and creates noise. Vibration-activated alarms can be made to activate when an unauthorised person opens the drawer of a cabinet or the door of a cupboard, etc., and thus creates a small amount of vibration in a protected object. Both types of circuit can use the same basic principle of operation, as illustrated in the block diagram of *Figure 5.16*.

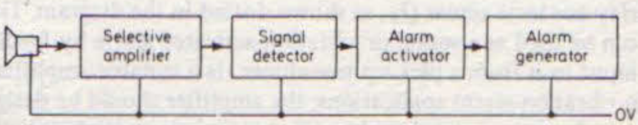



*Figure 5.16 Block diagram of typical sound or vibration alarm circuit*

Here, a microphone or similar transducer is used to pick up the basic noise or vibration of the environment, and the resulting signal is passed to a selective amplifier stage, which rejects unwanted signals and

amplifies the band of signals that are of interest. The output of this amplifier is fed to a signal detector stage, which converts the a.c. input to a d.c. output; the d.c. output is fed to an alarm activator, which responds to input levels in excess of a predetermined amount. Finally, the output of the alarm activator is fed to the actual alarm signal generator.

*Figure 5.17* shows the practical circuit of a simple but useful signal detector and alarm activator, which gives a relay output. The circuit needs an input of about 1 V a.c. to turn the relay on.

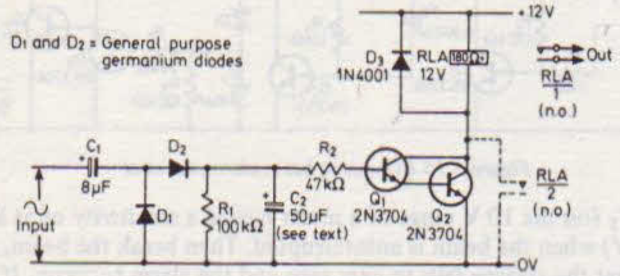



*Figure 5.17 Simple relay-output signal-detecting alarm activator; needs 1 V a.c. input to activate relay*

Here, the a.c. input signal is simply rectified and smoothed via $D_1-D_2-R_1$ and $C_2$, and the resulting d.c. is used to drive the relay on via $Q_1$ and $Q_2$. Normally, when zero input is applied, zero d.c. is developed across $C_2$, so $Q_1-Q_2$ and the relay are off. When an a.c. input of 1 V is fed to the circuit, roughly 2 V d.c. is developed across $C_2$, so $Q_1-Q_2$ and the relay are driven on. The circuit action is such that the relay turns on rapidly when a suitable input signal is connected, but turns off slowly when the signal is removed. The turn-off time is determined by the time constant of $R_1$ and $C_2$, and can be changed to suit specific requirements by altering the $C_2$ value.

The *Figure 5.17* circuit can be made self-latching by wiring a spare set of relay contacts across $Q_2$, as shown dotted in the diagram. The circuit can be used as a sound or vibration-activated alarm by feeding an a.c. input to it from a pick-up transducer via a suitable amplifier stage. In vibration-alarm applications, the amplifier should be designed to pass low-frequency signals only, and in sound-alarm applications it should be designed to pass the selected audio band only.

Finally, to conclude this chapter, *Figure 5.18* shows the circuit of an IC speech-frequency amplifier which can be used in conjunction with the *Figure 5.17* circuit to make a sensitive sound-activated alarm.

Here, sound is picked up by a 5 kΩ moving-coil microphone and is fed to pin 1 of the IC. The IC is a CA3035 ultra-high-gain wide-band amplifier array manufactured by RCA, and gives a voltage gain of about 120 dB between the input at pin 1 and the output at pin 7, so a vastly amplified version of the microphone signal appears at pin 7 and can be

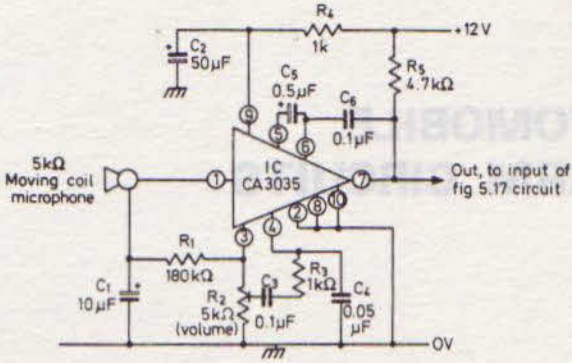



*Figure 5.18 Speech-frequency amplifier; can be used in conjunction with Figure 5.17 to make a sound-activated alarm*

fed to the input of the *Figure 5.17* circuit. $R_1$ and $C_1$ are bias components for the IC, and $R_5$ is a load resistor for one of the IC stages. $R_4$ $C_3-C_4-C_5$ and $C_6$ are coupling and frequency-compensation components for the IC, and $R_5$ is a load resistor for one of the IC stages, $R_4$ and $C_2$ provide a decoupled supply for two of the IC stages. The outline and pin numbers of the CA3035 IC are shown in the Appendix.

CHAPTER 6

# AUTOMOBILE ALARM CIRCUITS

Electronic alarms have a number of practical applications in automobiles. They can be used to give anti-theft protection, or to indicate a probability of ice on the road or of overheating in the engine or gearbox, or to warn the driver that he is running low on fuel. Sixteen useful automobile alarm circuits are presented in this chapter. Included among these are five immobilisers which, although not true 'alarms', give useful anti-theft protection.

### Types of anti-theft device

Vehicle anti-theft devices come in two basic types. The first of these is the 'immobiliser', which is intended simply to reduce a thief's chances of starting or driving away a target vehicle; it gives no protection against the car burglar, who merely wishes to steal objects that are left inside the vehicle. Immobilisers usually consist simply of a switch wired into some part of the electrical section of the vehicle's power unit, thus enabling the engine to be easily disabled.

The second type of anti-theft device is the true burglar alarm, which sounds an alarm (and perhaps also immobilises the vehicle's engine) if any unauthorised person tries to enter the vehicle. These alarms may be activated in one of three basic ways. One of the most popular ways is via microswitches that operate when any of the car doors, hood (bonnet)

or trunk (boot) is opened. Microswitch-activated alarms are fairly inexpensive, highly reliable, and can give excellent anti-theft protection.

Another way is by detecting the small drop that takes place in the vehicle's battery voltage when a door, hood or trunk courtesy-light turns on, or when the ignition is turned on. These so-called 'voltage sensing' alarms give the same degree of anti-theft protection as the microswitch types of alarm system, but are generally more expensive and less reliable.

A third way of activating an alarm is by detecting the vibration or swaying that takes place when a vehicle is entered or moved. This type of alarm has a number of disadvantages. If its sensitivity is adjusted so that it activates when anyone enters or rocks the vehicle, the system will tend to go off in gusty winds or when a person leans on the automobile. In this state the system has a very low reliability rating. Alternatively, if the system is adjusted so that it activates only when the vehicle is actually moved or subjected to substantial 'G' forces, it won't be sensitive enough to give effective anti-burglar protection. These systems can readily be made to give false alarms, so thieves can easily persuade their owners to disconnect them by repeatedly false-triggering the alarms.

Practical automobile anti-theft alarm systems can be switched on and off either from within the car or from outside. Systems that are switched from within the vehicle have a number of disadvantages. To enable the owner to leave the vehicle without activating the alarm, the system must incorporate a built-in 'exit' delay of about 30 seconds, and to enable the owner to enter the vehicle again it must have an additional built-in 'entry' delay of about 15 seconds.

Consequently the circuits tend to be fairly complex and expensive, and to have a relatively poor reliability rating. More important, the systems give very poor anti-burglar protection, since the thief is given a full 15 seconds of entry time in which to steal any worthwhile goodies before the alarm sounds off.

By contrast, externally-switched alarm systems can be very simple, reliable and inexpensive, and, since they can be made to sound off the instant that a car door starts to open, can be made to give excellent anti-burglar protection.

The comparative table of *Figure 6.1* shows the degree of protection offered by different types of anti-theft device against different types of thief. As can be seen, immobilisers give good protection against joy-riders and drive-away thieves, but give no protection against burglars or tow-away thieves, while externally-switched microswitch-activated and voltage-sensing alarms give good protection against all except tow-away thieves.

| | *Snatch burglar* | *Cassette thief* | *Joy-rider* | *Drive-away thief* | *Tow-away thief* |
|---|---|---|---|---|---|
| Immobiliser | Nil | Nil | Good | Good | Nil |
| Internally-switched microswitch-activated alarm | Nil | Good | Good | Good | Nil |
| Internally-switched voltage-sensing alarm | Nil | Good | Good | Good | Nil |
| Internally-switched vibration alarm | Nil | Poor | Good | Poor | Fair |
| Externally-switched microswitch-activated alarm | Good | Good | Good | Good | Nil |
| Externally-switched voltage-sensing alarm | Good | Good | Good | Good | Nil |
| Externally-switched vibration alarm | Poor | Poor | Good | Poor | Fair |

*Figure 6.1 Comparative table showing degree of protection given by different types of anti-theft device against different types of thief*

Having cleared up these points, let's now go on and look at some practical anti-theft circuits.

### Immobiliser circuits

Immobilisers simply reduce a thief's chances of starting or driving away a target vehicle. Simple immobilisers consist of a concealed switch wired into some part of the electrical section of the vehicle's power unit. *Figures 6.2* to *6.5* show a number of circuits of this type.

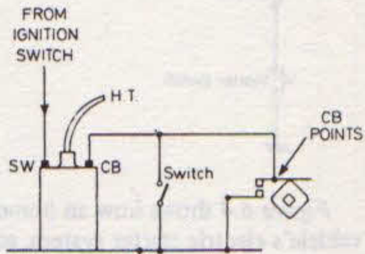



*Figure 6.2 Contact-breaker immobiliser, operates when switch is closed*

*Figures 6.2* and *6.3* show how immobilisers can be wired into the vehicle's ignition system. In *Figure 6.2,* the switch is wired across the vehicle's contact-breaker (CB) points. When the switch is open the ignition operates normally, but when the switch is closed the CB points

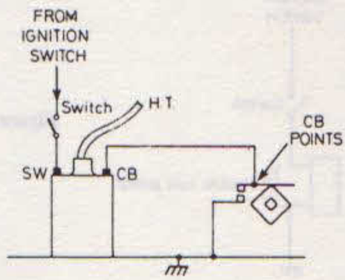



*Figure 6.3 Ignition immobiliser, operates when switch is open*

are shorted out and the engine is unable to operate. This circuit gives excellent protection, particularly if the wiring is carefully concealed at the CB end.

In the *Figure 6.3* circuit the immobiliser switch is wired in series with the vehicle's ignition switch, so that the engine operates only

when the switch is closed. The protection of this circuit is not as good as that of *Figure 6.2,* since a skilled thief can by-pass the immobiliser and ignition switches by simply hooking a wire from the battery to the SW terminal of the coil.

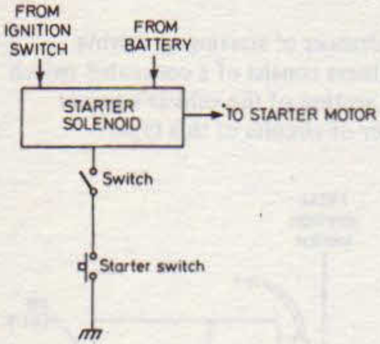



*Figure 6.4 Starter-motor immobiliser, operates when switch is open*

*Figure 6.4* shows how an immobiliser switch can be wired into the vehicle's electric starter system, so that the starter only operates if this switch is closed. This system gives better protection than *Figure 6.3,* but is not as good as *Figure 6.2* because the starter solenoid can be operated manually on many vehicles, and also because the starter and immobiliser switches can be by-passed by a single length of wire.

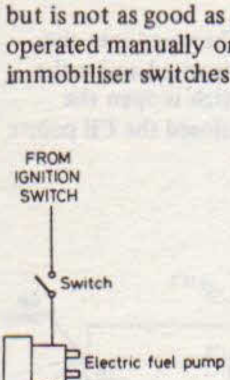



*Figure 6.5 Fuel-pump immobiliser, operates when switch is open*

Finally, *Figure 6.5* shows how an immobiliser switch can be wired in series with the electric fuel pump on suitable vehicles, so that the pump operates only when this switch is closed. A feature of this system is that it permits a thief to start the engine and drive for a short distance

on the fuel remaining in the carburettor before the lack of fuel-pump operation immobilises the vehicle.

A weakness of the *Figure 6.2* to *6.5* circuits is that they must all be turned on and off manually, so they only give protection if the owner remembers to turn them on. By contrast, *Figure 6.6* shows an immobiliser that turns on automatically when an attempt is made to start the engine, but that can be turned off by briefly operating a hidden push-button

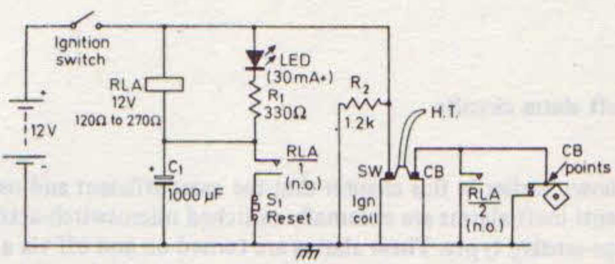



*Figure 6.6 Self-activating immobiliser circuit for negative-ground vehicles; for positive-ground vehicles reverse the polarities of* $C_1$ *and LED*

switch. A small 'reminder' light turns on when the engine is disabled by the immobiliser. This circuit thus gives a high degree of protection, since it does not depend on the memory of its owner. The circuit operates as follows.

The coil of relay *RLA* is wired in series with 1000 $\mu$F capacitor $C_1$, and the combination is wired across the vehicle's ignition switch. $C_1$ is shunted by the series combination of n.o. relay contacts *RLA*/1 and n.c. push-button switch $S_1$; n.o. relay contacts *RLA*/2 are wired across the vehicle's CB points; an LED (light-emitting diode) is wired in series with current-limiting resistor $R_1$, and the combination is wired across the relay coil.

Normally $C_1$ is fully discharged. Consequently, when the ignition switch is first closed a surge of current flows through the relay coil via $C_1$, and the relay turns on. As the relay goes on, contacts *RLA*/1 close and lock the relay on via $S_1$, and contacts *RLA*/2 close and short out the vehicle's CB points, thus immobilising the engine. Under this condition current flows in the LED via $R_1$, and the LED illuminates. The relay stays on until $S_1$ is briefly opened, at which point the relay unlatches and $C_1$ charges up rapidly via the relay coil, and the relay and the LED turn off. As the relay turns off, the short is removed from the

vehicle's CB points, and the engine is able to operate in the normal way.

The relay used in the *Figure 6.6* circuit can be any 12 V type with a coil resistance in the range 120 Ω to 270 Ω, and with two or more sets of n.o. contacts. The LED can be any type with a mean current rating greater than 30 mA. The circuit as shown is for use on vehicles with negative-ground electrical systems. On positive-ground vehicles, reverse the polarities of $C_1$ and the LED.

**Anti-theft alarm circuits**

It was shown earlier in this chapter that the most efficient and useful vehicle anti-theft alarms are externally-switched microswitch-activated or voltage-sensing types. These alarms are turned on and off via a concealed toggle-switch or a prominent key-switch fitted to the outside of the vehicle. *Figures 6.7* to *6.10* show practical examples of alarm systems of these types. All these circuits also act as immobilisers, operating the vehicle's horn and lights and immobilising the engine under the 'alarm' condition.

In the *Figure 6.7* to *6.9* circuits, microswitches that are built into the vehicle are used to trip a self-latching relay when any of the car doors, hood or trunk is opened; this relay immobilises the engine and operates the horn and headlights either directly or via additional circuitry. Two suitable front-door microswitches are built into most vehicles as standard fittings, and are used to operate the courtesy or dome lights. Additional switches can easily be fitted to the rear doors. The hood and trunk can be protected by 'auxiliary' microswitches.

The operation of the *Figure 6.7a* circuit is very simple. Normally, with the key-switch open, no voltage is fed to the relay network, so the alarm is off. Suppose, however, that the key-switch is closed. If any of the door switches close, current flows in the relays via $D_1$; if any of the auxiliary switches close, current flows via $D_2$. In either case, both relays turn on. As *RLA* goes on, contacts *RLA*/1 close and lock both relays on, and contacts *RLA*/2 close and short out the vehicle's CB points, thus immobilising the vehicle.

Simultaneously contacts *RLB*/1 close and switch on the car horn, giving an audible indication of the intrusion, and contacts *RLB*/2 close and switch on the headlights, giving a visual identification of the violated vehicle. The horn and lights remain on until the key-switch is opened, or until the vehicle's battery runs flat.

The *Figure 6.7a* circuit is for use on negative-ground vehicles. The circuit can be modified for use on positive-ground vehicles by simply reversing the polarities of $D_1$ and $D_2$, as shown in *Figure 6.7b.*

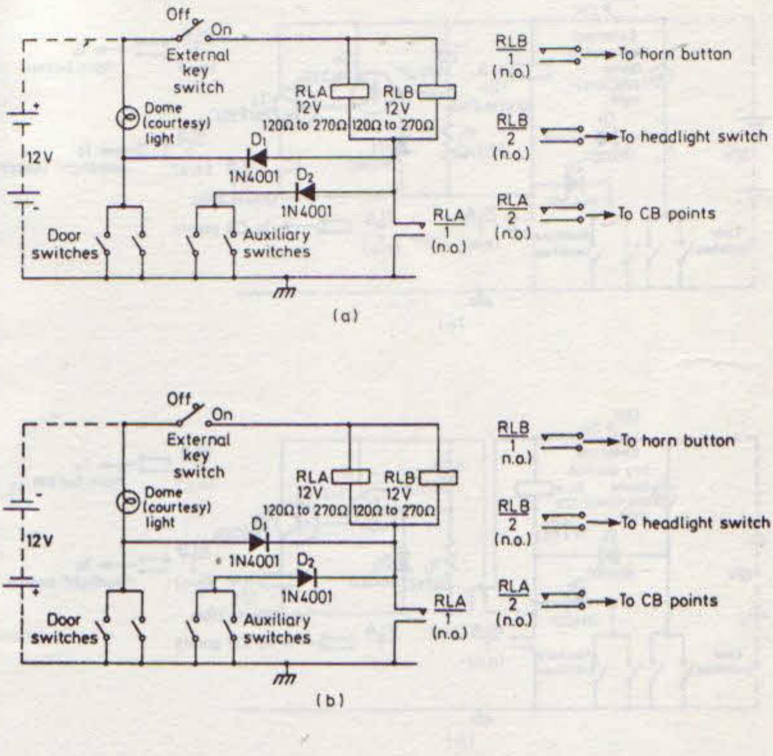



*Figure 6.7 Simple microswitch-activated anti-theft alarm/immobiliser, operates horn and lights until switched off or until battery runs flat; (a) negative-ground, (b) positive-ground*

A weakness of the simple *Figure 6.7* circuit is that, since car horns and their associated components are not designed to withstand continuous long-period operation, these components may be damaged if the alarm sounds for too long. *Figure 6.8a* shows how the *Figure 6.7a* circuit can be modified so that the horn and lights turn off automatically after four minutes or so, thus minimising the possibility of horn damage.

Here, *RLA* turns on and self-latches in the same way as in the *Figure 6.7a* circuit, and as contacts *RLA*/1 close the full battery voltage is applied across the $Q_1-Q_2-RLB$ network. At the moment that power is applied, $C_1$ is fully discharged and acting like a short-circuit, so the

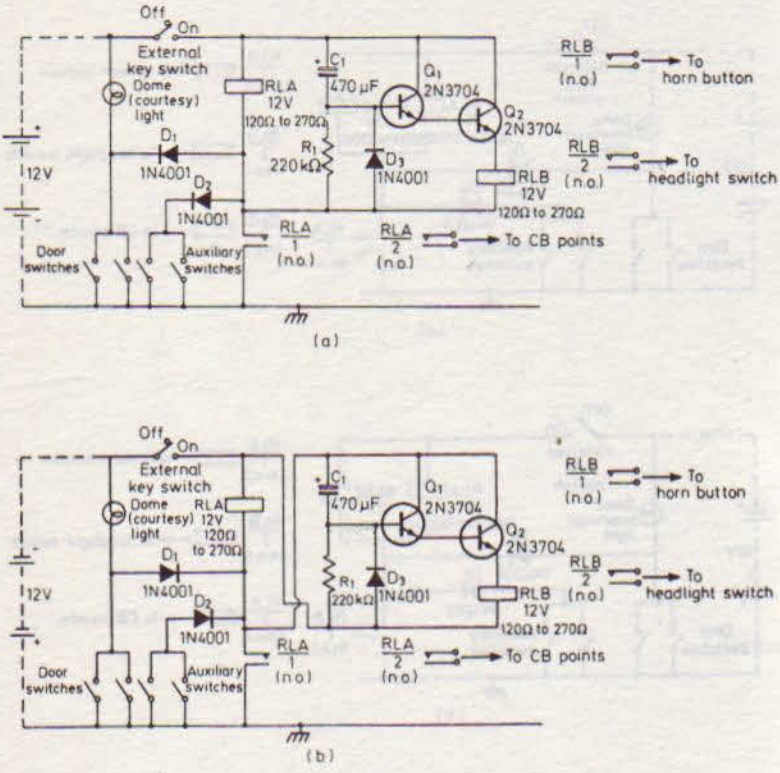



*Figure 6.8 Improved microswitch-activated anti-theft alarm/immobiliser, turns horn and lights off automatically after four minutes; (a) negative-ground, (b) positive-ground*

base and collector of $Q_1$ are effectively shorted together. *RLB* is thus immediately turned on via the $Q_1-Q_2$ Darlington emitter-follower, and the horn and lights operate.

As soon as the power is applied to the circuit, $C_1$ starts to charge up via $R_1$, and the voltage across the coil of *RLB* starts to decay exponentially towards zero. After a delay of about four minutes this voltage

falls so low that *RLB* and the horn and lights turn off. *RLA* remains on, however, until the system is turned off via the key-switch, so the vehicle remains immobilised via its CB points.

The *Figure 6.8a* circuit is for use on negative-ground vehicles. The circuit can be modified for use on positive-ground vehicles by reversing the polarities of $D_1$ and $D_2$, and reversing the supply connections to the *RLB*-driving network, as shown in *Figure 6.8b*.

A minor practical snag with the *Figure 6.8* circuit is that, since it gives a 'monotone' form of horn operation, its owner is unlikely to be

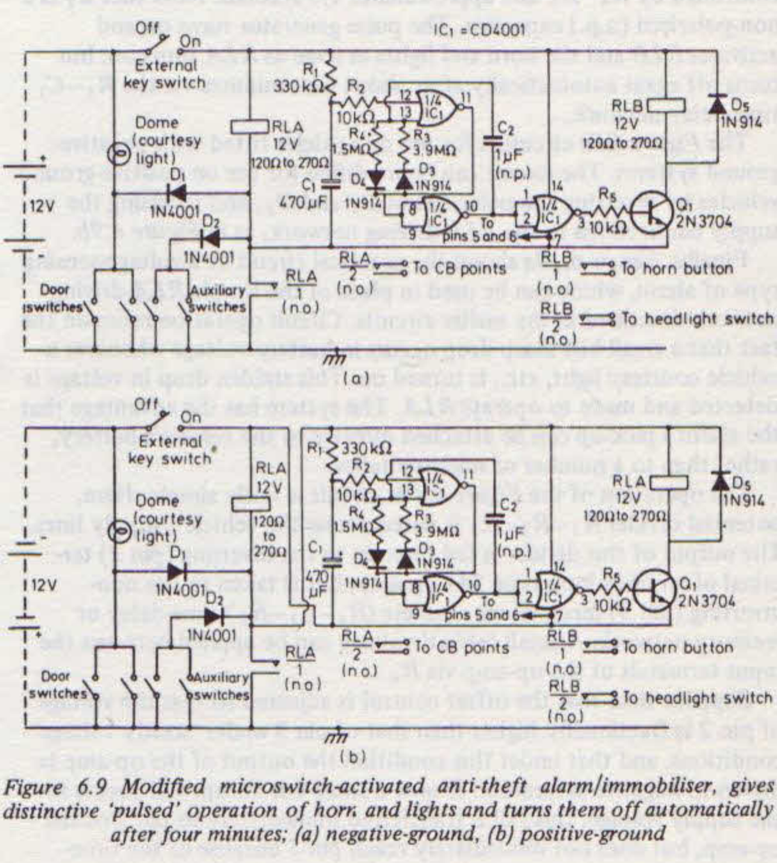


*Figure 6.9 Modified microswitch-activated anti-theft alarm/immobiliser, gives distinctive 'pulsed' operation of horn and lights and turns them off automatically after four minutes; (a) negative-ground, (b) positive-ground*

able to recognise the sound of his own vehicle, and will tend to check his own vehicle whenever he hears any horn sound off. This snag is overcome in the circuit of *Figure 6.9a*, which pulses the horn and

lights on for 4 seconds and off for 1.5 seconds repeatedly for about four minutes under the alarm condition, thus producing a very distinctive warning signal.

The *Figure 6.9a* circuit is similar to that of *Figure 6.8a*, except that *RLB* is driven by a pulse generator formed from $Q_1$ and a type CD4001 COS/MOS digital IC. The IC is wired as a buffered-output gated astable multivibrator, with unequal 'on' and 'off' times, and with its gating controlled by time-delay network $R_1-C_1$. The 'on' time of the relay is controlled by $R_3-D_3$ and approximates 4 seconds; the 'off' time is controlled by $R_4-D_4$ and approximates 1.5 seconds. Note that $C_2$ is a non-polarised (n.p.) capacitor. The pulse generator turns on and activates *RLB* and the horn and lights as soon as *RLA* turns on, but turns off again automatically after about four minutes via the $R_1-C_1$ time-delay network.

The *Figure 6.9a* circuit is for use on vehicles fitted with negative-ground systems. The circuit can be modified for use on positive-ground vehicles by reversing the polarities of $D_1$ and $D_2$, and reversing the supply connections to the *RLB*-driving network, as in *Figure 6.9b*.

Finally, *Figure 6.10a* shows the practical circuit of a voltage-sensing type of alarm, which can be used in place of the simple *RLA*-driving network described in the earlier circuits. Circuit operation relies on the fact that a small but sharp drop occurs in battery voltage whenever a vehicle courtesy light, etc., is turned on. This sudden drop in voltage is detected and made to operate *RLA*. The system has the advantage that the alarm's pick-up can be attached directly to the vehicle's battery, rather than to a number of microswitches.

The operation of the *Figure 6.10a* circuit is fairly simple. Here, potential divider $R_1-R_2-R_3$ is wired across the vehicle's supply lines. The output of this divider is fed directly to the inverting (pin 2) terminal of an open-loop type 741 op-amp, but is taken to the non-inverting (pin 3) terminal via a simple ($R_4-C_1-R_5$) time-delay or memory network. A small 'offset' voltage can be applied between the input terminals of the op-amp via $R_6$.

Suppose then that the offset control is adjusted so that the voltage of pin 2 is fractionally higher than that of pin 3 under 'steady voltage' conditions, and that under this condition the output of the op-amp is driven to negative saturation. If now a small but abrupt fall occurs in the supply voltage, this fall is transferred immediately to pin 2 of the op-amp, but does not immediately reach pin 3 because of the time-delay or memory action of $C_1$. Consequently, pin 2 briefly goes negative relative to pin 3, and as it does so the output of the op-amp is driven briefly to positive saturation, thus giving a positive output pulse. This pulse is used to charge $C_2$ via $D_1$, and $C_2$ drives $Q_1-Q_2$ and

the relay on via $R_8$. As the relay goes on, contacts *RLA*/1 close and cause the relay to self-latch, and contacts *RLA*/2 close and immobilise the vehicle via its CB points.

Note that the above circuit responds only to sudden drops in potential, and is not influenced by absolute values of battery voltage. Thus leaving the car lights, etc., on or off has no influence on the operation of the alarm system.

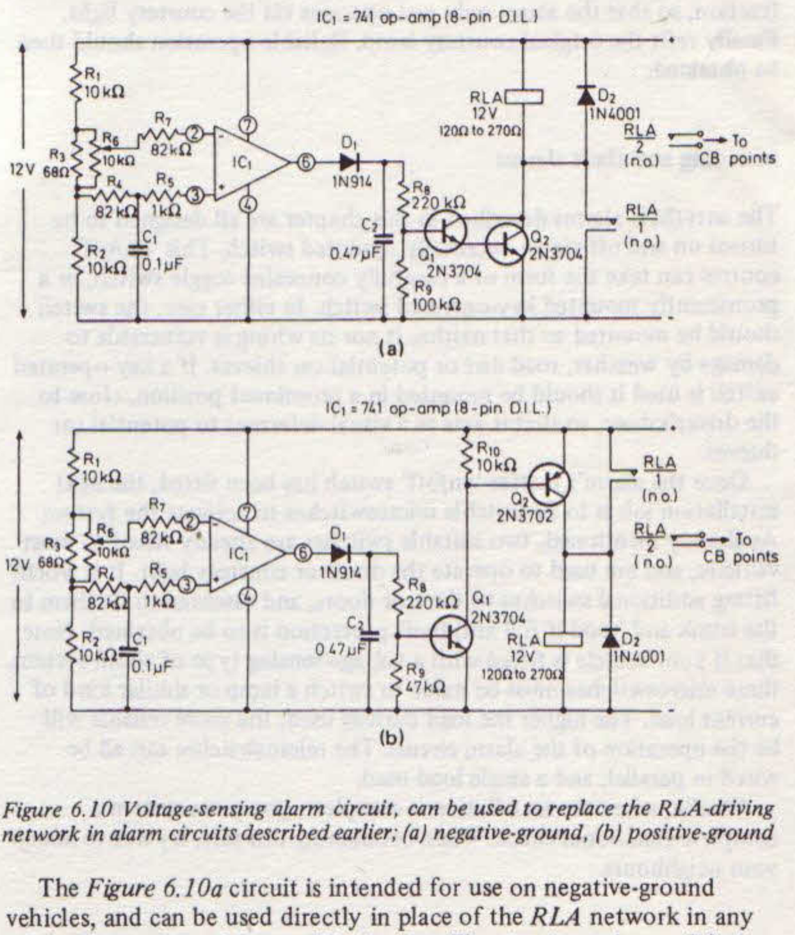



*Figure 6.10 Voltage-sensing alarm circuit, can be used to replace the RLA-driving network in alarm circuits described earlier; (a) negative-ground, (b) positive-ground*

The *Figure 6.10a* circuit is intended for use on negative-ground vehicles, and can be used directly in place of the *RLA* network in any of the *Figure 6.7a, 6.8a,* or *6.9a* circuits. The circuit can be modified for use on positive-ground vehicles by using the connections shown in *Figure 6.10b*, and can then be used directly in place of the *RLA* network in any of the *Figure 6.7b, 6.8b*, or *6.9b* circuits.

When installing the *Figure 6.10* circuit in a vehicle, $R_6$ must be adjusted so that the alarm turns on reliably when a courtesy light goes on, without being excessively sensitive to small shifts in battery voltage. To find the correct $R_6$ setting, proceed as follows.

First remove the courtesy lamp and replace it with one having half the original current rating. Now adjust $R_6$ just past the point where the alarm fails to operate when the lamp goes on, and then turn $R_6$ back a fraction, so that the alarm only just operates via the courtesy light. Finally refit the original courtesy lamp. Reliable operation should then be obtained.

## Installing anti-theft alarms

The anti-theft alarms described in this chapter are all designed to be turned on and off via an externally mounted switch. This 'on/off' control can take the form of a carefully concealed toggle switch, or a prominently mounted key-operated switch. In either case, the switch should be mounted so that neither it nor its wiring is vulnerable to damage by weather, road dirt or potential car thieves. If a key-operated switch is used it should be mounted in a prominent position, close to the driver's door, so that it acts as a visual deterrent to potential car thieves.

Once the alarm's master 'on/off' switch has been fitted, the next installation job is to fit suitable microswitches to activate the system. As already mentioned, two suitable switches are already fitted to most vehicles, and are used to operate the dome or courtesy light. It is worth fitting additional switches to the rear doors, and essential to fit them to the trunk and hood if full anti-theft protection is to be obtained. Note that if your vehicle is fitted with a voltage-sensing type of alarm system, these microswitches must be made to switch a lamp or similar kind of current load. The higher the load current used, the more reliable will be the operation of the alarm circuit. The microswitches can all be wired in parallel, and a single load used.

Finally, when the installation is complete, give your system a complete functional check. When conducting this test, try not to annoy your neighbours.

## Ice-hazard alarms

Ice-hazard alarms activate when the vehicle's ignition is turned on and the air temperature a little way above the road surface is at or below

0° C. The alarms thus indicate a hazard of meeting ice under actual driving conditions.

Two useful ice-hazard alarm circuits are shown in this section. In each case the circuits act as precision under-temperature alarms, and use a thermistor as a temperature sensor. The thermistor is mounted in the air-flow at the front of the vehicle, a little way above the road surface, and gives a good indication of the actual road temperature. Both circuits are based on designs already presented in Chapter 3.

The first circuit, shown in *Figure 6.11*, gives a relay-output warning of the ice-hazard, and is designed around a type 741 operational

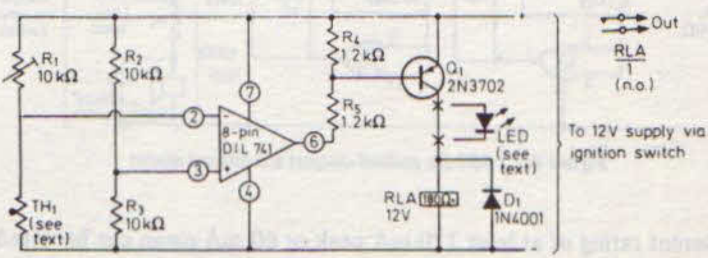



*Figure 6.11 Relay-output ice-hazard alarm*

amplifier. The design is based on that of *Figure 3.12*, and a full description of the circuit operation is given in Chapter 3. The following additional points should, however, be noted about the *Figure 6.11* circuit.

The relay used in the circuit can be any 12 V type with one or more sets of n.o. contacts and having a coil resistance of 180 Ω or greater. Any type of external alarm-indicator can be activated via the relay contacts.

If required, an LED can be made to activate when the alarm turns on, thus giving a visual indication of the alarm condition. When relays with coil resistances of 300 Ω or greater are used, the LED can be any type with a rating of 40 mA or greater, and can be wired in series with the relay coil as indicated in the circuit diagram. Alternatively, if a coil resistance less than 300 Ω is used, a more sensitive LED can be wired in series with a suitable current-limiting resistor and the combination can be wired in parallel with the relay coil.

The second circuit, shown in *Figure 6.12*, gives an 800 Hz pulsed-output loudspeaker warning of the ice-hazard, and is designed around a

CD4001 COS/MOS IC. The design is based on that of *Figure 3.15a,* and a full description of the circuit operation is given in Chapter 3.

The speaker used in the *Figure 6.12* circuit can have any impedance in the range 3 Ω to 100 Ω, and the value of $R_x$ should be chosen to give a combined series impedance of 100 Ω. If required, an LED with

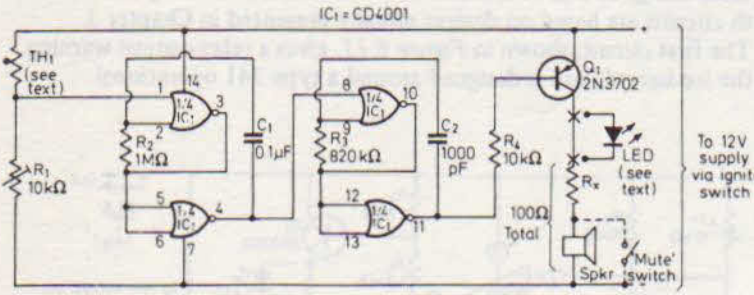



*Figure 6.12 800 Hz pulsed-output ice-hazard alarm*

a current rating of at least 120 mA peak or 60 mA mean can be wired in series with $R_x$ (as in the diagram) to give a visual indication of the alarm condition. A useful addition to the *Figure 6.12* circuit is a muting switch, to reduce the speaker volume once the alarm call has been noted. The volume can be reduced to zero by wiring the switch directly across the speaker as shown, or can be reduced to a preset level by wiring a limiting resistor (value found by trial and error) in series with the switch.

The power connections of both ice-hazard alarm circuits should be taken to the vehicle's battery via the ignition switch, so that the circuits are automatically energised whenever the vehicle is in use. On vehicles that use an ignition dropper resistor, the connections can be taken to the battery via an ignition-switch-activated relay contact.

The thermistors used in the two circuits can be any negative-temperature-coefficient types that present a resistance in the range 1 kΩ to 10 kΩ at 0°C. Each thermistor must be mounted in a small 'head' that is fixed to the lower front of the vehicle, and connected to the main alarm-unit via twin flex. To make the thermistor head, solder the thermistor to a small tag-board and solder its leads to the twin flex. Coat the whole assembly with waterproof varnish, so that moisture will not affect its apparent resistance, then mount it in a small plastic or metal box and fix it to the lower front of the vehicle. Before fixing the head in place, however, calibrate the alarm system as follows.

Immerse the head in a small container filled with a water and ice mixture. Use a thermometer to measure the temperature of the mixture, and add ice until a steady reading of 0°C is obtained. Now adjust $R_1$ so that the alarm just turns on; raise the temperature slightly, and check that the alarm turns off again. If satisfactory, the head and the alarm system can now be fixed permanently to the vehicle.

## Overheat-warning alarms

Each of the ice-hazard alarms of *Figures 6.11* and *6.12* can be modified so that it activates when its thermistor temperature goes above (rather than below) a preset value. In such cases the thermistor can be used as a probe that can be bonded to any fixed part of the vehicle. The circuits can thus be used to warn the driver of overheating in the engine, gearbox, differential, brake drums, etc. Two practical overheat-warning alarm circuits are presented in this section.

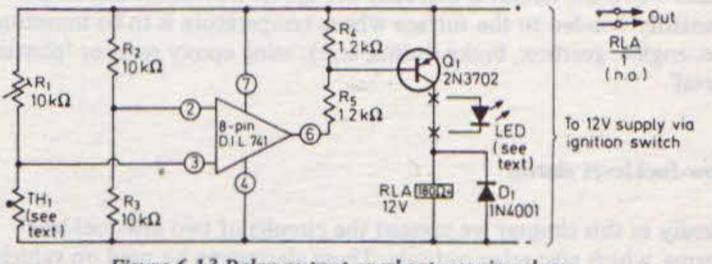



*Figure 6.13 Relay-output overheat-warning alarm*

The first circuit, shown in *Figure 6.13*, gives a relay-output warning of the overheat condition, and is identical to the *Figure 6.11* ice-hazard alarm, except that the pin 2 and pin 3 input connections of the op-amp are transposed, so that the alarm activates when the temperature goes above (rather than below) a preset value.

The second circuit, shown in *Figure 6.14*, gives an 800 Hz pulsed-output loudspeaker warning of the overheat condition, and is identical to the *Figure 6.12* ice-hazard alarm, except that the positions of $R_1$ and the thermistor are transposed, so that the alarm activates when the temperature goes above a preset value.

The notes applying to the use of LEDs, muting switches, relay types

and thermistor types, etc., in the section on ice-hazard alarms also apply to the two overheat circuits of *Figures 6.13* and *6.14*.

To set up either circuit, raise its thermistor to the desired overheat alarm temperature, and adjust $R_1$ so that the alarm just turns on. Then

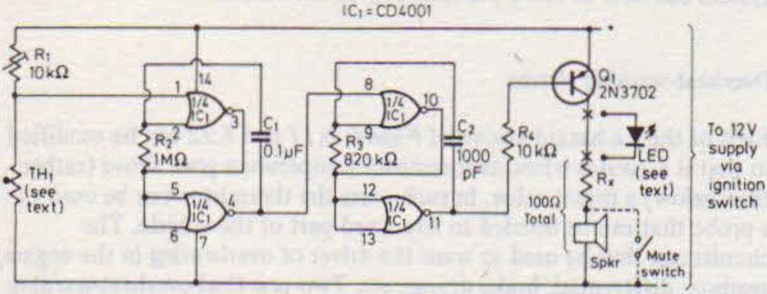



*Figure 6.14 800 Hz pulsed-output overheat-warning alarm*

reduce the temperature slightly, and check that the alarm turns off again. When the circuit is correctly set up, its thermistor can be permanently bonded to the surface whose temperature is to be monitored (i.e. engine, gearbox, brake drums, etc.), using epoxy resin or 'plastic metal'.

## Low-fuel-level alarms

Finally in this chapter we present the circuits of two low-fuel-level alarms, which give relay outputs. These alarms can be used on vehicles fitted with a 12 V electrical system and with a fuel gauge of the type that is actuated via a fuel-tank-mounted potentiometer, in which the voltage developed across the potentiometer is proportional to the fuel level, i.e. the voltage decreases as the fuel level falls. The alarms need a minimum input (from the potentiometer) of 1.5 V for satisfactory operation.

To find out if the alarms are suitable for use in your own vehicle, simple measure the voltage across the tank-mounted potentiometer, or between the 'low' terminal of the fuel gauge and ground: check that a steady voltage reading is obtained, roughly proportional to the fuel level, and greater than 1.5 V under the required low-fuel-level alarm condition.

The circuit of the negative-ground version of the alarm is shown in *Figure 6.15*. Here, $Q_1$ and $Q_2$ are wired as a simple differential voltage amplifier, with its output feeding to relay-driving transistor $Q_3$, and $Q_2$

and $Q_3$ are wired together as a regenerative switch, with backlash controlled via $R_5$ and $R_6$. One input of the differential amplifier is derived from the fuel gauge via $D_1$–$R_1$ and $C_1$, which form a simple smoothing network and ensure that the $Q_1$ base voltage corresponds to the mean

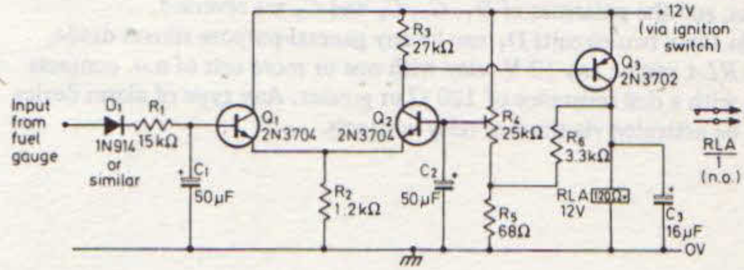



*Figure 6.15 Relay-output low-fuel-level alarm, negative-ground*

(rather than instantaneous) input voltage. The other input is derived from the 12 V supply line via $R_4$, which sets a reference voltage on the base of $Q_2$. $C_2$ and $C_3$ ensure that neither the amplifier nor the relay is influenced by supply-line transients or rapid changes in the vehicle's battery voltage.

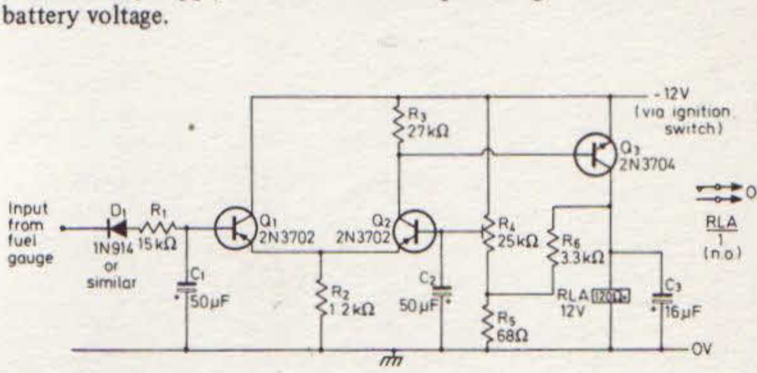



*Figure 6.16 Relay-output low-fuel-level alarm, positive-ground*

The action of the circuit is such that the relay is normally off, but turns on when the voltage on the base of $Q_1$ (from the fuel gauge) falls below that of $Q_2$ (the reference voltage). Once the relay has turned on, the value of the reference voltage is automatically increased via the regenerative action of $Q_2$ and $Q_3$. Thus the alarm turns on as soon as the voltage from the fuel-gauge (and thus the fuel level) falls below a

preset value, but once it has turned on the relay does not turn off again until the fuel level rises appreciably above the initial trigger level.

Finally, the positive-ground version of the low-fuel-level alarm is shown in *Figure 6.16.* This circuit is identical to that of *Figure 6.15*, except that npn transistors are used in place of pnp types, and vice versa, and the polarities of $D_1$, $C_1$, $C_2$ and $C_3$ are reversed.

In these two circuits $D_1$ can be any general-purpose silicon diode, and *RLA* can be any 12 V relay with one or more sets of n.o. contacts and with a coil resistance of 120 $\Omega$ or greater. Any type of alarm device can be activated via the n.o. relay contacts.

CHAPTER 7

# INSTRUMENTATION ALARM CIRCUITS

Instrumentation alarms can be used to activate a lamp or other visual indicator when a monitored voltage or resistance, etc., goes beyond preset limits. In this final chapter we present a dozen simple but useful instrumentation alarm circuits that can be used to monitor a.c. or d.c. voltages or currents, or resistance. Most of the circuits are designed around an 8-pin d.i.l. type 741 operational amplifier.

All the circuits are designed to give an LED (light-emitting diode) output, thus giving a visual indication of the alarm condition. This LED can be any type having a mean current rating up to 40 mA, and must be wired in series with a current-limiting resistor, shown as $R_y$ in the circuit diagrams. $R_y$ must have its value chosen to match the current rating of the LED to the supply voltages that are used with each circuit. The formula for finding the value of this resistor is

$$R_y = \frac{V_{supply} - 2}{I_{LED}}$$

Thus, if the circuit has a 12 V supply and the LED is a 40 mA (= 0.040 A) type, $R_y$ must be given a value of roughly 250 Ω. Note that if a circuit uses two sets of supplies (such as +9 V and −9 V), $V_{supply}$ must be taken as the difference between the two supply voltages (= 18 V in this example). In the circuits, $R_y$ is shown as having a nominal value of 330 Ω, and this value should be close enough to 'correct' for most practical purposes.

**D.C. voltage alarm circuits**

*Figure 7.1* shows the practical circuit of a precision d.c. over-voltage alarm, which works with inputs in excess of 5 V only. Here, the op-amp is used in the open-loop mode as a d.c. voltage comparator, with a zener-derived 5 V reference signal applied to the non-inverting pin of

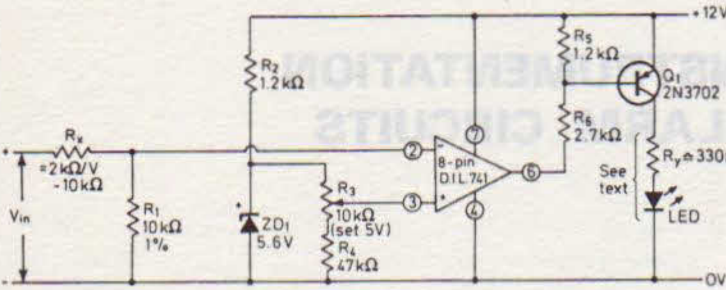



*Figure 7.1 Precision d.c. over-voltage alarm, covering 5 V upwards*

the op-amp via $R_3$, and the test voltage applied between the inverting pin and ground. The circuit action is such that the op-amp output is positively saturated, and $Q_1$ and the LED are off, when the inverting pin voltage is fractionally less than the 5 V reference potential, and $Q_1$ and the LED go on when the inverting pin voltage is fractionally greater than the 5 V reference potential.

$R_X$ is wired in series between the input test voltage and the 10 kΩ impedance of the inverting pin of the op-amp, and enables the circuit to be ranged so that it triggers at any required voltage in excess of the 5 V reference value. The $R_X$ value for any required trigger voltage is determined on the basis of 2 kΩ/V – 10 kΩ. Thus, for 50 V triggering, $R_X$ = (50 × 2 kΩ) – 10 kΩ = 90 kΩ. For 5 V triggering, $R_X$ must have a value of zero ohms.

The *Figure 7.1* circuit is very sensitive and exhibits negligible backlash. Triggering accuracies of 0.5 per cent can easily be achieved. For maximum accuracy, either the power supply or the zener reference voltage of the circuit should be fully stabilised.

The *Figure 7.1* circuit can be made to function as a precision under-voltage alarm, which turns on when the input voltage falls below a preset level, by transposing the inverting and non-inverting pin connections of the op-amp, as shown in *Figure 7.2*. This circuit also shows how the zener reference supply can be stabilised for high-precision operation.

Note in both of these circuits that, once 5 V has been accurately set via $R_3$, the final triggering accuracy of each design is determined solely by the accuracies of $R_x$ and $R_1$. In high-precision applications, therefore, these resistors should be precision wire-wound types.

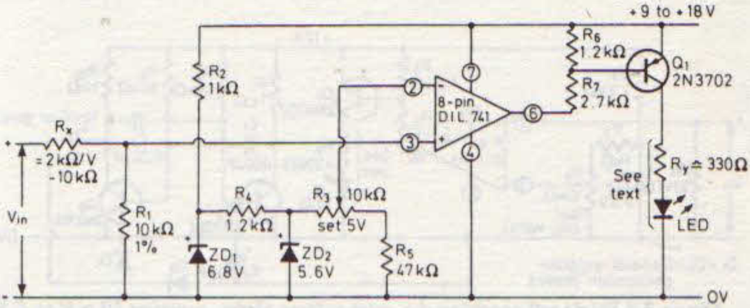



*Figure 7.2 Precision d.c. under-voltage alarm, covering 5 V upwards*

*Figure 7.3* shows how the *Figure 7.1* circuit can be modified for use as an over-voltage alarm covering the range 10 mV to 5 V. In this case the input voltage is connected directly to the inverting terminal of the op-amp, and a variable reference potential is applied to the non-inverting terminal. This reference potential is adjusted to give the same value as

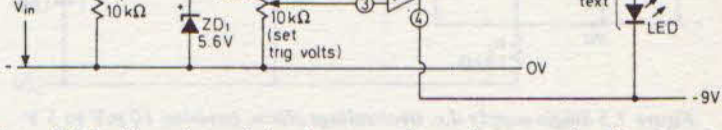



*Figure 7.3 Dual-supply precision d.c. over-voltage alarm, covering 10 mV to 5 V*

that of the required trigger voltage. The circuit action can be reversed, so that the design acts as an under-voltage alarm, by transposing the input pin connections of the op-amp. Note that the *Figure 7.3* circuit uses two sets of supply lines, to ensure proper biasing of the op-amp.

*Figure 7.4* shows how the *Figure 7.3* circuit can be adapted for operation from a single set of supply lines. Here $Q_2$ and $Q_3$ are wired as an astable multivibrator or square-wave generator, and the output of this generator is used to provide a negative supply rail for the op-amp via voltage-doubling and smoothing network $D_1-D_2$ and $C_3-C_4$. The

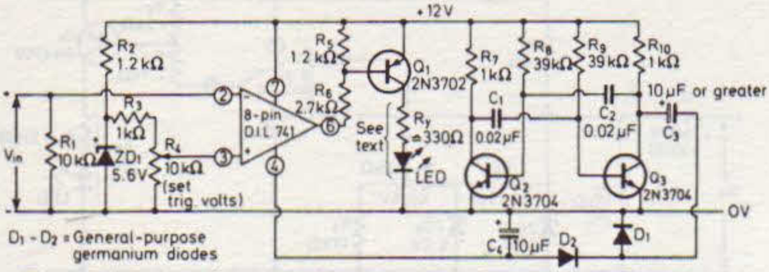



*Figure 7.4 Single-rail precision d.c. over-voltage alarm, covering 10 mV to 5 V*

doubler gives a negative output of about 9 V when unloaded, but gives only 3–5 volts when connected to pin 4 of the op-amp.

Finally, *Figure 7.5* shows the circuit of a d.c. over-voltage alarm that covers the range 10 mV to 5 V and uses a single floating supply. Here, the op-amp is again used as a d.c. voltage comparator, but its positive

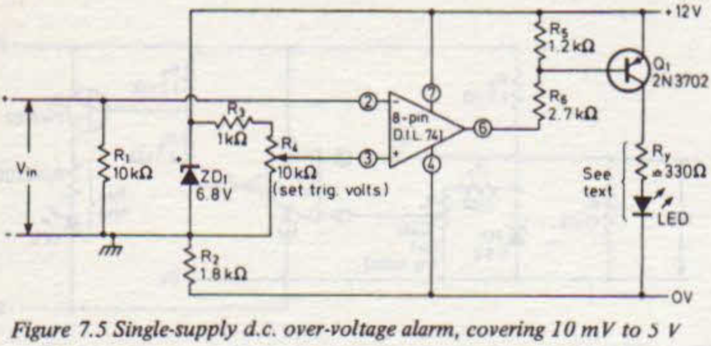



*Figure 7.5 Single-supply d.c. over-voltage alarm, covering 10 mV to 5 V*

supply rail is set at 6.8 V via the floating supply and zener diode $ZD_1$, and its negative rail is set at −5.2 V via the $ZD_1$ and $R_2$ combination. The monitored input signal is fed to the inverting terminal of the op-amp, and a zener-derived reference potential is fed to the non-inverting terminal via $R_3$ and $R_4$. This reference potential can be varied between

roughly 10 mV and 5 V, and this is therefore the voltage range covered by the over-voltage alarm.

**A.C. voltage alarm circuits**

The five voltage-activated alarms shown in *Figures 7.1* to *7.5* are designed for d.c. activation only. All these circuits can be modified for a.c. activation by interposing suitable rectifier/smoothing networks or

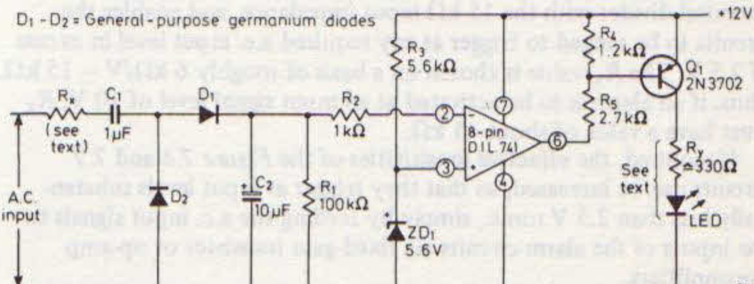



*Figure 7.6 Precision a.c. over-voltage alarm, covering 2.5 V upwards*

a.c./d.c. converters between their input terminals and the actual a.c. input signals, so that the a.c. signals are converted to d.c. before being applied to the alarm circuits.

*Figure 7.6* shows the practical circuit of a precision a.c. over-voltage alarm that is designed to work with sine-wave signals in excess of

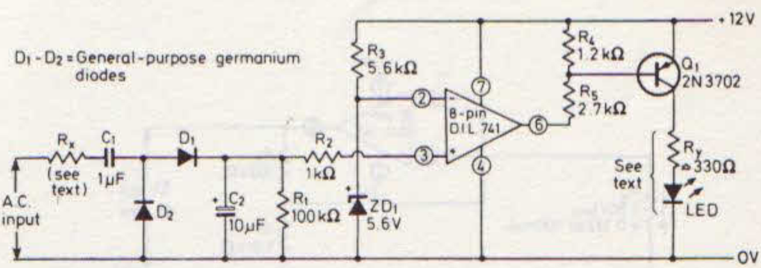



*Figure 7.7 Precision a.c. under-voltage alarm, covering 2.5 V upwards*

2.5 V r.m.s. Here, the a.c. signal is converted to d.c. via voltage doubling and smoothing network $R_X-C_1-D_1-D_2-C_2-R_1$, and the resulting d.c. voltage is applied to the inverting input of the op-amp via $R_2$. A zener-derived 5.6 V reference potential is applied to the non-inverting

terminal. The circuit action is such that the alarm turns on when the d.c. voltage on the inverting terminal exceeds 5.6 V.

The action of the above circuit can be reversed, so that it works as an under-voltage alarm, by transposing the input terminal connections of the op-amp, as shown in *Figure 7.7.*

The circuits of *Figures 7.6* and *7.7* both exhibit a basic input impedance, with $R_X$ reduced to zero ohms, of about 15 kΩ, and under this condition a sine wave of about 2.5 V r.m.s. is needed to activate the alarm. Consequently, when $R_X$ is given a finite value it acts as a potential divider with the 15 kΩ input impedance, and enables the circuits to be ranged to trigger at any required a.c. input level in excess of 2.5 V. The $R_X$ value is chosen on a basis of roughly 6 kΩ/V – 15 kΩ. Thus, if an alarm is to be activated at an input signal level of 10 V, $R_X$ must have a value of about 45 kΩ.

If required, the effective sensitivities of the *Figure 7.6* and *7.7* circuits can be increased, so that they trigger at input levels substantially less than 2.5 V r.m.s., simply by feeding the a.c. input signals to the inputs of the alarm circuits via fixed-gain transistor or op-amp preamplifiers.

## Current alarm circuits

Each of the five d.c. voltage alarm circuits of *Figures 7.1* to *7.5* can be used as a d.c. current alarm by simply feeding the monitored current to the input of the voltage alarm via a current-to-voltage converter. A suitable converter circuit is shown in *Figure 7.8.*

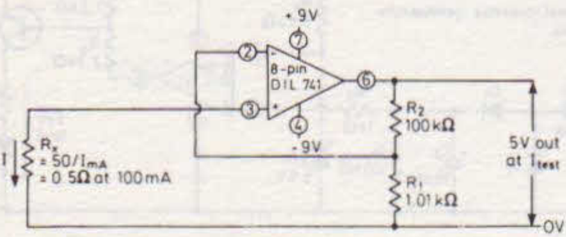



*Figure 7.8 D.C. current-to-voltage converter*

Here, the op-amp is wired as a non-inverting x 100 voltage amplifier, with gain determined by the ratios of $R_1$ and $R_2$. The test current is passed through input resistor $R_X$, which has its value chosen so that

50 mV is developed across it at the required trigger current, thus giving 5 V output from the op-amp under this condition. The $R_X$ value is selected on the basis of

$$R_X = \frac{50}{I_{mA}}$$

where $I_{mA}$ is the desired trigger current in milliamps. Thus $R_X$ needs a value of 0.5 Ω at trigger levels of 100 mA, or 0.05 Ω at trigger levels of 1 A.

A similar type of converter circuit, using a.c. coupling, can be used to enable the *Figure 7.6* and *7.7* circuits to act as a.c. current alarms.

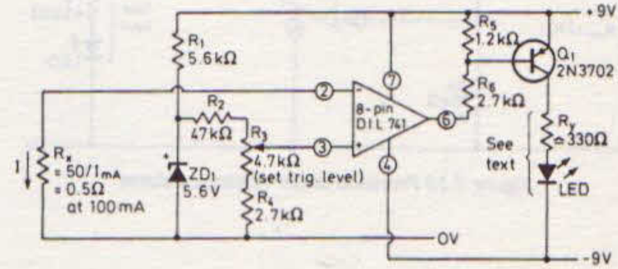



*Figure 7.9 D.C. over-current alarm*

If required, an op-amp circuit can be built specifically for use as a d.c. current alarm. *Figure 7.9* shows an over-current version of such a circuit. Here, $R_X$ is again used to develop a potential of 50 mV at the desired current level, and this voltage is applied to the inverting pin of the op-amp. A zener-derived reference potential of approximately 50 mV is applied to the non-inverting terminal of the op-amp. This reference voltage can be adjusted over a limited range via $R_3$, thus providing a limited control of the circuit's sensitivity.

Thus the *Figure 7.9* alarm circuit turns on when the current-derived input voltage exceeds the 50 mV potential of the reference voltage. The action of the circuit can be reversed, so that it acts as an under-current alarm, simply by transposing the connections to the two input terminals of the op-amp. In either case, the value of monitor resistor $R_X$ is chosen on the basis of

$$R_X = \frac{50}{I_{mA}}$$

**Resistance alarms**

*Figure 7.10* shows the practical circuit of a precision under-resistance alarm, which turns on when the value of a monitored resistance falls below a preset value. Here, the op-amp is again used as a voltage

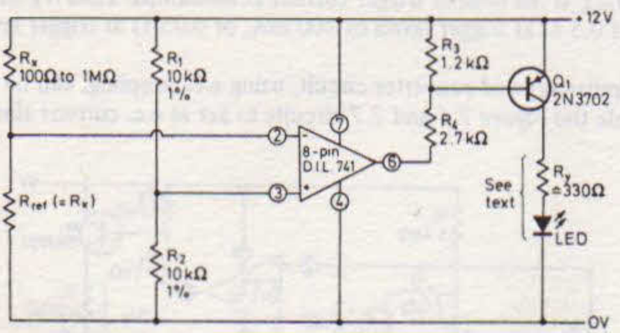



*Figure 7.10 Precision under-resistance alarm*

comparator, with its output feeding to the LED visual indicator via $Q_1$, but in this case the voltage to the non-inverting pin of the op-amp is set at half-supply volts via potential divider $R_1 - R_2$, and the voltage on the inverting pin is determined by the ratios of $R_x$ and $R_{ref}$. In effect, these four resistors are wired as a Wheatstone bridge, and the circuit action is such that the alarm turns on when the value of $R_x$ falls below that of reference resistor $R_{ref}$, i.e. when the bridge goes out of balance in such a way that the voltage on the inverting terminal rises above that of the non-inverting terminal of the op-amp.

$R_x$ and $R_{ref}$ must have equal values, but can be given any values in the range 100 Ω to 1 MΩ. The minimum resistance value is dictated by the current-driving capability of the circuit's power supply, and the maximum value is restricted by the shunting effect that the input of the op-amp has on the effective value of $R_{ref}$.

The accuracy of the above circuit is independent of variations in power-supply voltage, and the alarm is capable of responding to changes of less than 0.1 per cent in the value of $R_x$. The actual accuracy is determined by $R_1 - R_2$ and $R_{ref}$, and in worst-case terms is equal to the sum of the tolerances of these three resistors, i.e. it equals ±3 per cent if 1 per cent resistors are used.

The action of the above circuit can be reversed, so that it acts as a precision under-resistance alarm, by transposing the input pin connections of the op-amp, as shown in *Figure 7.11*. This circuit also shows

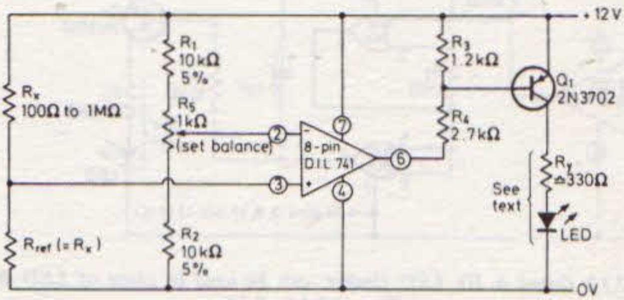



*Figure 7.11 Precision over-resistance alarm*

how the accuracies of both designs can be improved by adding $R_5$ 'set balance' control to the $R_1-R_2$ divider chain. This control enables the bridge to be precisely balanced, so that the alarm turns on when the value of $R_x$ varies from the marked value of $R_{ref}$ by only 0.1 per cent or so. In this case the true accuracy of the circuit is equal to the tolerance of $R_{ref}$ plus 0.1 per cent.

## An LED flasher circuit

All of the circuits that we have looked at in this final chapter are intended to be built into electronic instruments, and have a simple LED output that is intended to be fitted to the front panel of the instrument and to turn on and illuminate under the alarm condition. Each of these circuits can be modified, if desired, so that the LED flashes on and off rapidly under the alarm condition, thus giving a more attention-catching indication that a fault has occurred. *Figure 7.12* shows the circuit of the LED flasher, together with details of how it can be added to the alarm circuits.

Here, two of the gates of a CD4001 COS/MOS digital IC are wired as a gated 6 Hz astable multivibrator, and the output of this astable is used to drive the LED via $R_3$ and $Q_1$. Normally, when the pin 1 terminal of the IC is high, the astable is disabled and the LED is off. When

pin 1 goes low, on the other hand, the astable is gated on and pulses the LED on and off at a rate of roughly 6 Hz. The rate can be altered by changing the $R_2$ value.

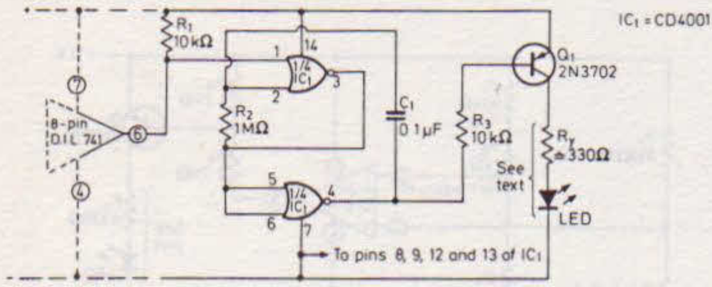


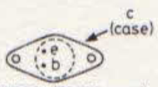

*Figure 7.12 Gated 6 Hz LED flasher, can be used in place of LED driver in Figures 7.1 to 7.11*

The LED flasher circuit uses the existing power supplies of the alarm circuits, and is used in place of the existing LED driver networks. Pin 1 of the COS/MOS IC is simply connected directly to output pin 6 of the op-amp of the alarm circuit. *Note:* the supply voltage between pins 7 and 14 of the IC must not exceed 18 V.

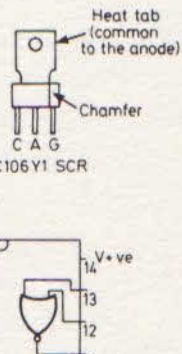
# SEMICONDUCTOR OUTLINES AND PIN DESIGNATIONS

NOTE: In case of difficulty, U.K. readers can obtain all semiconductor devices mentioned in this volume from Arrow Electronics Ltd, 7 Coptfold Road, Brentwood, Essex.

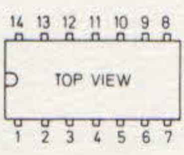

2N3702 and 2N3704 transistors



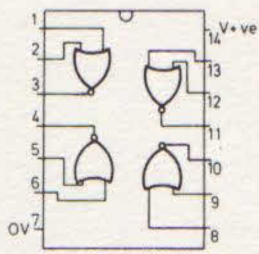

2N3054 (TO-66 case) and 2N3055 (TO-3 case) transistors



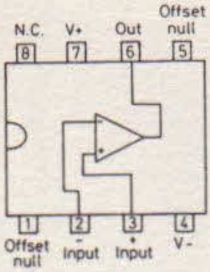

C106Y1 SCR



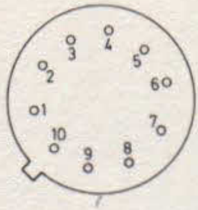

14-pin D.I.L. outline used on the CD4001




Pin designations of the CD4001 quad 2-input NOR gate




8-pin D.I.L. 741 op-amp (top view)




CA3035 pin connections (TO-5 case)

# INDEX

# 110 ELECTRONIC ALARM PROJECTS FOR THE HOME CONSTRUCTOR

This is the latest addition to the author's popular series of electronics project books. It brings together 110 useful alarm circuits of a variety of types to intrigue the amateur, the student and the engineer.

Electronic alarms have a multitude of applications in the home, in industry and in the car. They can be designed to be activated by physical contact or proximity, by variations in light or heat levels, or by variations in voltage, current resistance or some other electrical property. They may give high-level audible outputs, as in the case of burglar alarms and car anti-theft alarms, or low-level visual outputs, as in the case of instrumentation alarms.

The operating principle of each circuit in this book is explained in concise but comprehensive terms, and brief constructional notes are given where necessary. All the circuits have been designed, built and fully evaluated by the author. They are designed around a variety of types of readily available semiconductor devices of American manufacture.

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